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USSR Report

PHYSICS AND MATHEMATICS

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7 May 1984

USSR REPORT
PHYSICS AND MATHEMATICS

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CRYSTALS AND SEMICONDUCTORS

EFFECT OF PHOTO-STIMULATED CURRENT OSCILLATIONS IN SEMICONDUCTOR STRUCTURE

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 38, No 5, 10 Sep 83 (manuscript received 12 Jul 83) pp 244-246

KNAB, O. D. and FROLOV, V. D.

[Abstract] The authors have discovered photosensitive current oscillations in silicon structures with p-n junction. This phenomenon was further studied in an experiment with epitaxial silicon structures where the p-n junction had been formed by growing a thin slightly doped n-type film on a heavily doped p-type substrate. The n-region of this p-n junction was illuminated from a GaAs infrared light-emitting diode at the $0.9 \mu\text{m}$ wavelength. The current-voltage characteristics were measured without illumination (breakdown voltage about 55 V) and at various levels of illumination power up to $1610 \mu\text{W}$. The voltage dependence of the oscillation frequency was also measured and the frequency found to be consistently higher with than without illumination, ranging from a fraction of a kilohertz to a few megahertz. Illumination was found to trigger current oscillations at a threshold voltage below the dark-current breakdown voltage, a different threshold level for every illumination power level, with the oscillation frequency depending almost linearly on the illumination power. Sweeping the surface of the semiconductor structure with the light spot revealed a sensitivity of the oscillation frequency to the location of the light spot, the frequency reaching maximum with the light spot at the center and dropping to minimum with the light spot on the periphery, but no such sensitivity of the oscillation amplitude. Further studies are needed for explaining the mechanism of this phenomenon, the evidence available so far indicating a negative feedback through the n-layer. The authors thank V. A. Afanas'yev, V. L. Bonch-Bruyevich, V. M. Buymistrov, G. I. Epifanov, A. N. Georgyani and A. P. Shotov for helpful discussions. Figures 3.

[18-2415]

STRUCTURE OF AMORPHOUS As_2S_3 FILMS

Baku IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR: SERIYA FIZIKO-TEKHNICHEISKIH I MATEMATICHESKIKH NAUK in Russian Vol 4, No 2, 1983 (manuscript received 17 Jul 82) pp 75-78

EFENDIYEV, E. G. and SHAFIZADE, R. B., Institute of Physics

[Abstract] The nearest-order structure in amorphous As_2S_3 films has not yet been definitively determined, mainly because of wide variances in the technology of such films. The purpose of this study was to determine the nearest-order parameters in 300 Å thick amorphous As_2S_3 films produced from glassy bulk material at constant evaporation rate (approximately 50 Å/min) and temperature (approximately 250°C) on celluloid and NaCl substrates. Electron diffraction patterns were processed on a YeS-1022 Unified System computer, which has revealed three halos corresponding to interplanar distances $d_1 = 2.93 \text{ \AA}$, $d_2 = 1.71 \text{ \AA}$, $d_3 = 1.14 \text{ \AA}$ respectively, and has yielded a curve of normalized electron scattering intensity (75 keV electrons). Subsequent Fourier transformation of the scattering intensity has yielded the radial distribution of atoms. The results indicate that an elementary scattering unit in amorphous As_2S_3 is a tetrahedron with a sulfur atom at the center and an arsenic atom at each vertex. The authors thank V. I. Shil'nikov, group leader in Department of Computer Engineering, for performing calculations on the YeS-1022 computer. Figures 3, references 7: 5 Russian, 2 Western. [23-2415]

NARROW-BAND FILTRATION OF MICROWAVE SIGNAL

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 9, No 21, 12 Nov 83 (manuscript received 1 Apr 83, after final editing 14 Jun 83) pp 1281-1284

VASHKOVSKIY, A. V., VORONENKO, A. V., ZUBKOV, V. I. and KIL'DISHEV, V. N., Institute of Radio Engineering and Electronics, USSR Academy of Sciences, Moscow

[Abstract] The feasibility of producing narrow-band microwave filters on the basis of volume magnetostatic waves in (YIG) films has been established both theoretically and experimentally. Ensuring a frequency band so narrow as to contain only one frequency of natural magnetostatic vibrations was achieved by use of a grating for conversion of electromagnetic signals to volume magnetostatic waves and by matching the geometrical dimensions of the film, particularly making its thickness sufficiently small for only one pass band. With this desirable feature attained, it becomes possible to utilize the inherent advantages of YIG-film filters with volume magnetostatic waves over those with surface magnetostatic waves (which have a notched amplitude-frequency characteristic consisting of wider bands with mild slopes) and over globular YIG filters (which are bulky, not producible by planar technology,

and have a Lorentzian amplitude-frequency characteristic). A prototype filter was built with a YIG film of 8x2x0.006 mm size, a grating (21 strips, each 25 μm wide, spaced uniformly with a period of 100 μm), two 0.5 mm wide segments of a strip line for input and output-1 respectively, and another such segment for output-2 parallel to the grating. This filter has a 0.46 Oe wide resonance line and a 4 MHz wide pass band or stop band with 10.1 or 5 dB/MHz slopes respectively. Figure 1, references 8: 4 Russian, 4 Western.
[14-2415]

UDC 621.382

NEGATIVE DIFFERENTIAL CONDUCTIVITY IN QUASI-TWO-DIMENSIONAL SEMICONDUCTOR SUPERLATTICES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 273, No 6, Dec 83
(manuscript received 17 May 83) pp 1351-1354

IGNATOV, A. A., Institute of Applied Physics, USSR Academy of Sciences, Gorkiy

[Abstract] Negative differential conductivity, a nonlinear effect of high electric field intensity, is considered in the quasi-two-dimensional variant of a superlattice, specifically a superlattice of dimensionally quantized GaAlAs layers with an energy miniband bounded from two directions and with a fixed energy in the direction perpendicular to the layers. Fluctuation and high-frequency characteristics of such a superlattice are analyzed, taking into account not only the finiteness of particle motion in all quasi-momentum directions but also the fast dissipation of electron energy as a result of electron scattering by optical phonons. The correlation function for fluctuations of the current carrier velocity is calculated, revealing that the velocity correlator is an oscillatory function of time with a frequency equal to the frequency of Bloch oscillations of carriers in the miniband and with a characteristic attenuation time equal to the characteristic relaxation time in the system. The complete pattern of negative differential conductivity in a typical GaAlAs structure ($d = 100 \text{ \AA}$, a $\Delta = 0.1 \text{ eV}$, $T = 300 \text{ K}$) with acoustical and optical scattering has been reconstructed on the basis of analytical and numerical data on negative mobility and relaxation time. These data include the frequency dependence of the minimum electric field intensity at which a negative differential conductivity appears in the current-voltage characteristic and of the electric field intensity at which this negative differential conductivity is maximum. The frequency range of negative differential conductivity is found to be rather wide, covering the range of submillimetric-wave radiation. The author thanks A. A. Andronov, A. M. Belyantsev and V. I. Shashkin for discussion and helpful comments. Articles was presented by Academician A. V. Gaponov-Grekhov on 21 April 1983. Figures 2, references 13: 6 Russian, 7 Western.
[6-2415]

TEMPERATURE DEPENDENCE OF PLASMA VIBRATION FREQUENCY OF FREE CHARGE CARRIERS IN SOME NARROW-GAP FERROELECTRIC SEMICONDUCTORS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 25, No 11, Nov 83
 (manuscript received 23 Jun 83) pp 3492-3494

KUKHARSKIY, A. A., MAL'TSEV, A. S. and NASYBULLIN, R. A., Leningrad State Pedagogical Institute imeni A. I. Gertsen

[Abstract] The changes in the plasma reflection spectra of narrow-gap ferroelectric semiconductors such as $Pb_{1-x}Sn_xTe$ compounds caused by temperature changes indicate a strong temperature dependence of the plasma vibration frequency of free charge carriers in these materials. One interpretation of this temperature dependence has been the existence of two valence bands with an energy gap between them which narrows as the temperature rises. Another interpretation has been a temperature dependence of the high-frequency permittivity, possibly associated with the ferroelectric phase transition. The latter hypothesis was tested experimentally, and somewhat modified on the basis of careful measurements of the plasma vibration spectra of $Pb_{0.8}Sb_{0.2}Te$ and $Pb_{0.6}Sb_{0.4}Te$ with the temperature varied smoothly from 80 to 300 K. An "IFS-113v" Fourier spectrometer (Brucker Co.) recorded spectra of normal specular reflection within the 200-4000 cm^{-1} range of wave numbers. The shift of the reflection spectra toward shorter waves and the deepening of their dips with decreasing temperature indicate, respectively, a higher plasma vibration frequency and a longer relaxation time with resulting higher carrier mobility. Above the Debye temperature (about 130 K) the temperature dependence of the dielectric permittivity (approximately inversely proportional to the plasma vibration frequency squared) is linear and similar to the Curie-Weiss law. Below the Debye temperature it is much less temperature-dependent and tends to become constant. The decrease of the short-wave reflection coefficient with decreasing temperature provides an independent confirmation of the second hypothesis. Figures 2, tables 1, references 4: 3 Russian, 1 Western.
 [5-2415]

DEPENDENCE OF ELECTRON SCATTERING INTENSITY IN $Bi_{1-x}Sb_x$ SEMICONDUCTOR ALLOYS COMPOSITION

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 25, No 11, Nov 83
 (manuscript received 3 May 83) pp 3454-3455

POZHERA, R. Yu. and TOLUTIS, R. B., Institute of Semiconductor Physics, LiSSR Academy of Sciences, Vilnius

[Abstract] The pressure dependence of cyclotron mobilities and electron concentration in $Bi_{1-x}Sb_x$ ($0.09 \leq x \leq 0.15$) was measured at 77 K by a noncontact high-frequency magnetoplasma method in rectangular single crystals of these

semiconductor alloys. The second cyclotron mobility (in the plane perpendicular to the binary crystallographic axis) has been found to peak at some pressure, at which a gapless state is induced, this critical pressure increasing almost linearly with the Sb content (from 0.4 GPa for $x=0.09$ to 0.6 GPa for $x=0.15$). Subsequent measurements at constant pressures have revealed that this mobility decreases as the Sb content increases, which indicates that adding Sb increases the intensity of electron scattering. Such a decrease of mobility is not caused by a changing position of the Fermi level but rather by increasing imperfection of the crystal lattice. Figures 2, references 7: 3 Russian, 4 Western.

[5-2415]

UDC 537.311.33

COHERENT PAIRING OF EXCITONS IN BOSE CONDENSATE OF BIEXCITONS IN SEMICONDUCTORS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 25, No 11, Nov 83
(manuscript received 24 May 83) pp 3282-3285

BOBRYSHCHEVA, A. I. and MOSKALENKO, S. A., Institute of Applied Physics, MSSR Academy of Sciences, Kishinev

[Abstract] It is demonstrated theoretically that coherent pairing of excitons with wave vectors k and $-k$ respectively is precisely Bose-Einstein condensation of biexcitons into a state with $k_B=0$. The proof is based on representing the hamiltonian of excitons in the secondary-quantization form with only the chemical potential and the Fourier transform of the interaction potential, and applying the canonical Bogolyubov transformation. With the chemical potential made to ensure stability of the new ground state and with no elementary excitations occurring at the temperature $T=0$, an equation is obtained which in the lower approximation coincides with the Schrödinger momentum equation for motion of two excitons in a biexciton. In the two extreme cases of either ortho- and para-excitons or four kinds of excitons with different projections of electron and hole spins, the level of an exciton shifts in the Hartree-Fock approximation toward higher energy. The method of analysis is the same as that used by L. V. Keldysh and A. N. Kozlov for coherent pairing of electrons and holes in the case of low exciton concentration. References 11: 2 Russian, 9 Western.

[5-2415]

MECHANISMS OF RADIATIVE RECOMBINATION OF HIGH-DENSITY EXCITONS IN CdS CRYSTALS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 25, No 11, Nov 83
 (manuscript received 9 Nov 82, after final editing 11 May 83) pp 3243-3249

DNEPROVSKIY, V. S., KLIMOV, V. I., MARTYNENKO, Ye. D. and STADNIK, V. A.,
 Moscow State University imeni M. V. Lomonosov

[Abstract] Four mechanisms of radiative recombination in strongly excited CdS crystals are examined by comparing the results of computer-aided calculations with the actual shape of corresponding lines in the spontaneous-luminescence spectra. These mechanisms are inelastic exciton-exciton scattering (P-line), inelastic exciton-electron scattering (E-line), annihilation of electron-hole equilibrium liquid (L-line) and annihilation of electron-hole plasma (Q-line). Three of these lines (P,L,Q) predominate in the spectrum at a temperature $T = 8$ K and a power density S of the excitation pulse within the $0.3-3$ MW/cm^2 range. The same lines predominate in the spectrum at $T = 80$ K within this range of S , but the P-line and the E-line predominate alternately as the excitation level rises. On the basis of such calculations and measurements the authors evaluated the spectral-kinetic characteristics of emission in CdS crystals, the parameters of a high-density exciton gas, and the kinetics of emission upon excitation by ultrashort light pulses. It is further possible to estimate the gain, considering that the condition for emission to begin predominance of amplifications over attenuation. Typical such estimates are shown for a CdS crystal with an excitation region $d \approx 40$ μm in diameter and with a reflection coefficient at its boundaries $R \approx 0.4$ ($\lambda \approx 350$ cm^{-1} at $S \approx 20$ MW/cm^2). Figures 5, references 16: 10 Russian, 6 Western.

[5-2415]

CRYSTAL STRUCTURE OF DIORTHOSILICATE $\text{NaBaNd}(\text{Si}_2\text{O}_7)$

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 271, No 2, Jul 83
 (manuscript received 24 Feb 83) pp 349-353

BATURIN, S. V., MALINOVSKIY, Yu. A. and BONDAREVA, Institute of Geochemistry and Analytical Chemistry imeni V. I. Bernadskiy and Institute of Crystallography imeni A. V. Shubnikov, USSR Academy of Sciences, Moscow

[Abstract] A study of synthetic $\text{Na},\text{Ba},\text{Nd}$ -diorthosilicate single crystals was made for a determination of their structural constitution and parameters. These crystals were produced from the $\text{NaOH}-\text{BaO}-\text{Nd}_2\text{O}_3-\text{SiO}_2-\text{H}_2\text{O}$ system by the hydrothermal method ($T = 500^\circ\text{C}$, $p \approx 1$ kbar), a subsequent x-ray spectral qualitative analysis with "Kamebaks" equipment revealing Ba and Nd in an approximately 1:1 ratio. The lattice parameters were determined in a CAD-4F

"Enraph-Nonius" auto-diffractometer and decoding of the structure yielded the chemical formula $\text{NaBaNd}(\text{Si}_2\text{O}_7)$, with $Z=8$ and the density $\rho=4.51 \text{ g/cm}^3$. Reflections were measured by the $/2\theta$ method ($\theta=35^\circ$) with variable scanning rate, using Mo K as radiation source and a graphite monochromator, whereupon the data were processed on an M-220M computer according to the "Kristall" program package. The coordinates of "heavy" (Ba, Nd) atoms in the crystal lattice were determined from the three-dimensional distribution of Patterson peaks and could be almost exactly (except for the second sign) pairwise referred to the inversion center. The locations of "light" (Na, O, Si) atoms were found to be apparently centrisymmetric, considering the large standard deviations in both isotropic and anisotropic approximations, also the large variance of isotropic thermal corrections for atom pairs and the degeneracy of thermal-vibration ellipsoids. The basic crystal structure is a three-dimensional one consisting of closely packed two Ba nonaons (large irregular polyhedra: twisted trigonal prisms) and two Nd heptaons (trigonal prisms with centered lateral face) with Na pentaons and Si_2O_7 groups in the interstices. The two Si_1 and Si_2 tetrahedra in an Si_2O_7 group bind the large cationic polyhedra within one layer and between layers respectively. The authors thank L. A. Muradyan for valuable comments on refinement of the structural conceptualization, V. A. Kuznetsov and I. P. Kuz'min for assistance in preparation of crystal specimens. Figures 3, tables 3, references: 4 Russian.

[8-2415]

UDC 535.372

QUENCHING LUMINESCENCE OF TERBIUM IN $(\text{Ce}_{0.67}\text{Tb}_{0.33})\text{MgAl}_{11}\text{O}_{19}$ BY SOME IMPURITIES

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 39, No 5, Nov 83
(manuscript received 9 Aug 82) p 867

BYKOVSKIY, P. I., POPOV, V. V., SUYATIN, B. D., RUSMAN, I. I. and CHUMAK, S. A.

[Abstract] A study was made pertaining to the effect of chromium ions, contained in Al_2O_3 as an uncontrolled impurity, on the luminescence of terbium. The excitation spectra of cerium, terbium, and chromium contain a common 308 nm band, which is also the luminescence excitation band of $\text{CeMgAl}_{11}\text{O}_{19}$. The excitation energy was found to be transferred from cerium ions to chromium ions indirectly, through terbium ions, the energy transfer from terbium ions to chromium ions being nonradiative. The effect of rare-earth impurities in CeO_2 (Nd, Sm, Pr) and in Tb_4O_7 (Dy, Y, Gd) on the intensity of terbium luminescence was measured by the method of incremental doping. An impurity of 10% Nd, Sm, Pr decreases the intensity of terbium luminescence by 90, 40, 50% respectively, while the presence of Dy, Y, Gd has no effect on it. Article deposited at All-Union Institute of Scientific and Technical Information under No 3020-83.

[4-2415]

EFFECT OF ELECTROFORMING PROCESS ON CHARACTERISTICS OF ELECTROLUMINESCENT FILM CAPACITORS

Minsk ZHURNAL PRIKLADNOY SPEKTR^SKOPII in Russian Vol 39, No 5, Nov 83
 (manuscript received 28 Jul 82) pp 785-789

VASIL'CHENKO, V. P. and MATUZEN, L. L.

[Abstract] An experimental study was made of electroluminescent capacitors containing a $ZnS < Mn >$ film (1 μm thick with 1 wt.% Mn) between two Y_2O_3 dielectric films (0.25 μm thick), with conducting glass as substrate and an aluminum electrode on the other side. Electroluminescence with a spectrum characteristic of manganese (peak at 585 nm wavelength) was excited by application of a sinusoidal alternating voltage, its amplitude varied over the 100-200 V range and its frequency varied over the 1-20 kHz range. The glow buildup and its temperature dependence as well as the dependence of its time constant on the excitation level and on the length of holding time in ON state were measured, also the glow intensity and the thermopolarization current before and during electroforming. The results of these measurements reveal that electroforming tends to stabilize the brightness-voltage characteristic at a smaller slope, while adding to it a hysteresis, with attendant decrease of the capacitor current and disappearance of background glow so that the integral brightness also decreases. All these changes are interpreted as resulting from changes in the highly defective fine-grain structure, where the intergranular space plays an important role and may be acting as "binder" for the entire film. The authors thank G. G. Pershin and M. A. Rodkin for preparation of specimens. Figures 4, references 4: 3 Russian, 1 Western.

[4-2415]

GIANT OPTICAL NONLINEARITY AND BISTABILITY IN DEPOSITED SEMICONDUCTOR FILMS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 10, Oct 83 pp 1963-1967

APANASEVICH, S. P., GONCHAROVA, O. V., KARPUSHKO, F. V. and SINITSYN, G. V., Institute of Physics, BSSR Academy of Sciences

[Abstract] The giant optical nonlinearity in thin-film semiconductor interferometers produced by vacuum evaporation, and used in logic devices for optical data processing, is analyzed from the standpoint of controlling the characteristics of light beams. Experiments were performed with interference light filters containing intermediate ZnS or $ZnSe$ layers. A hysteresis relation between the intensity of transmitted light and the intensity of incident light was attained by using 0.335 μm ZnS layers and 0.309 μm $ZnSe$ layers.

with the transmission peak 1.46 and 1.76 nm wide respectively. A modulated approximately gaussian light beam from an Ar-laser ($\lambda = 514.5$ nm) was focused through a lens onto a spot 50 μm in diameter on the surface of such a nonlinear interferometer. The threshold power of incident radiation for a bistable response of an interferometer with a ZnSe center layer was found to be approximately 7.5 mW, corresponding to 450 W/cm^2 . Logic devices with these interferometers remained stable at room temperature. After transition to bistability, no change of characteristics occurred for many hours in ZnS interferometers but irreversible changes occurred in ZnSe interferometers during short transient processes involving absorption of light and causing a shift of the transmission band toward shorter wavelengths. The response speed of logic devices was measured by probing with a He-Ne laser beam ($\lambda = 632.8$ nm), after nonlinear changes had been induced in the interferometers by Ar-laser pulses ($\lambda = 0.53 \mu\text{m}$) of 100 ns duration. Both experiment and calculation, based on relaxation kinetics, have yielded a response speed of the order of 10^{-5} s. A model of the giant optical nonlinearity in polycrystalline ZnS and ZnSe is proposed on the basis of these results, taking also into account the dispersion characteristics with additive contributions of individual absorption bands. This model can be used for determining the magnitude of light-induced absorption and changes in the complex refractive index. Figures 2, tables 1, references 12: 10 Russian, 2 Western.

[12-2415]

UDC 621.373.826

OPTICAL HYSTERESIS WITH PHASE-CONJUGATE REFLECTION IN SEMICONDUCTORS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 10, Oct 83 pp 1925-1930

KUKHTAREV, N. V., BORSHCH, A. A., BRODIN, M. S., VOLKOV, V. ..., SEMENETS, T. I. and STARKOV, V. N., Institute of Physics, UkrSSR Academy of Sciences

[Abstract] Phase conjugation via degenerate four-wave mixing is analyzed in compound semiconductors considering that dynamic gratings are recorded in such semiconductors principally by the optically nonlinear mechanism of free carrier generation. The concentration of electron-hole pairs induced during absorption of light is found from the appropriate equation of continuity, which takes into account diffusion of electron-hole pairs and their recombination through impurity centers. The efficiency of phase-conjugation in this case is determined by the conditions for phase or spatial synchronism of interacting oppositely propagating waves. The conditions for spatial synchronism can be violated by geometrical deviation of the wave vectors from their ideal orientation corresponding to geometrical synchronism. An analysis of this phenomenon on the basis of the parametric-diffraction model reveals self-diffraction leading to nonlinear phase deviation and optical feedback, which in this case causes optical hysteresis and bistability of the conjugate wave with an N-form dependence of its intensity on the intensity of the second pumping wave. The results of theoretical analysis were checked experimentally

with CdS crystals and an Rb-laser emitting pulses of 0.1 J energy and 15 ns duration. A complete interpretation of the experimental results must take into account the thermooptic effect at high pumping intensity and that the conjugate reflectance depends on the angle (noncollinearity) between the two pumping waves. Accordingly, optical hysteresis is found to occur in a CdS crystal at pumping intensities above 20 MW/cm^2 . Figures 1, references 9: 5 Russian, 4 Western.

[12-2415]

NONLINEARLY ACTIVE MATERIAL $(\text{La}_{1-x}\text{Nd}_x)_3\text{Ga}_5\text{SiO}_{14}$

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 10, Oct 83 pp 1903-1909

KAMINSKIY, A. A., MILL', B. V., SIL'VESTORVA, I. M. and KHODZHABAGYAN, G. G., Institute of Crystallography imeni A. V. Shubnikov, USSR Academy of Sciences

[Abstract] In search for a technologically producible disordered oxygen-bearing crystal with high concentration of Nd^{3+} ions as laser source, the complete series of $(\text{La}_{1-x}\text{Nd}_x)_3\text{Ga}_5\text{SiO}_{14}$ single crystals was synthesized by the Czochralski method with Malvern MRS-2 automatic equipment. For reference, self-activated $\text{Nd}_3\text{Ga}_5\text{SiO}_{14}$ ($x=1$) corresponds to $c_{\text{Nd}} = 100\% = 1.05 \cdot 10^{22} \text{ cm}^{-3}$.

The melting points of all these materials are in the vicinity of 1470 K, their optical transparency windows spread over the $0.24\text{--}5.5 \mu\text{m}$ range of wavelengths, and their refractive index at the wavelength of Nd^{3+} ions is

$n_e = \frac{A}{(24.1432 - (200\pi/\lambda)^2 - 1)^{1/2}}$ ($A = 61.41.24$ or 60.4341 , λ - wavelength in nm). In this study the authors determined their luminescence absorption spectra at 77 and 300 K, spectral characteristics of emission at 77 and 300 K, number and location of "Stark" levels of the Nd^{3+} quasi-center in the crystals at 77 K, and concentration dependence of laser wavelength and threshold excitation energy, for $^4\text{F}_{3/2} \rightarrow ^4\text{I}_{11/2}$ and $^4\text{F}_{3/2} \rightarrow ^4\text{I}_{13/2}$ transitions (multiplet $^4\text{I}_{9/2}$ also existing in these crystals). Supplementary data were also obtained on the optically positive uniaxial $\text{La}_3\text{Ga}_5\text{SiO}_4$ crystal, namely its elastic, piezoelectric, and dielectric constants, electromechanical coupling coefficients, Poisson ratios, electrical volume resistivity, and acoustic velocities. An analysis of its nonlinear properties indicates that in the $\text{La}_3\text{Ga}_5\text{SiO}_{14}$ crystal it is not possible to attain phase synchronism of eeo type for conversion of laser radiation from Nd^{3+} ions at 1.06 and $1.37 \mu\text{m}$ wavelengths to second-harmonic radiation. The authors thank V. G. Dmitriyev, A. F. Konstantinov, Yu. V. Pisarevskiy, M. I. Polyakov, Ye. V. Rayevskiy and S. E. Sarkisov. Figures 2, tables 6, references 8: 6 Russian, 2 Western.

[12-2415]

FLUID DYNAMICS

UDC 539.3

PROPAGATION OF LONGITUDINAL WAVES THROUGH MULTILAYER HALF-SPACE

Baku IZVESTIYA AKADEMII NAUK AZERBAYDZANSKOY SSR: SERIYA FIZIKO-TEKHNICHESKIKH I MATEMATICHESKIKH NAUK in Russian Vol 4, No 2, 1983 (manuscript received 25 May 82) pp 43-48

RASULOV, M. B., Institute of Mathematics and Mechanics

[Abstract] The transient problem of wave propagation through multilayer media is solved for longitudinal one-dimensional elastic waves propagating through an arbitrary number of successive layers of various thicknesses. The problem is reduced to a system of fundamental wave equations for appropriate initial and boundary conditions. The solution is sought in Laplace transforms of displacements and stresses, with all constant coefficients evaluated in terms of material density and acoustic velocity of layers. The general results are applied to the specific case of a single layer on a half-space of a different material. A layer of half-wavelength thickness is found not to affect an incident longitudinal wave, while the latter produces maximum stress at the center of that layer and the magnitude of this stress depends on the ratio of the wave impedances of the two materials. References: 3 Russian.
[23-2415]

UDC 533.6.011.72

PROPAGATION VELOCITY OF WEAK PERTURBATIONS IN WATER CONTAINING VAPOR BUBBLES

Moscow DOKLADY AKADEMII NAUK SSR in Russian Vol 273, No 6, Dec 83
(manuscript received 30 Jun 83) pp 1355-1358

KUZNETSOV, N. M., TIMOFEYEV, Ye. I., POLENOV, A. N. and GUBANOV, A. V.,
Institute of Chemical Physics, USSR Academy of Sciences, Moscow

[Abstract] An experimental study was made of slowly propagating perturbation waves in a two-phase medium consisting of water with a low concentration of vapor. Inside the low-pressure compartment of a shock tube were placed two boilers, one first heating the water to 100°C and the other (W-form nichrome

coil) then generating fine vapor bubbles. Agglomeration of vapor bubbles was avoided and the effect of a high water column under the 1.5 m long high-pressure compartment was eliminated by not immersing the W-heater too deep. Pressure transients and pressure waves in moist vapor were recorded on an oscilloscope and measured with piezoelectric transducers. No slow waves (1 m/s at vapor concentration $\theta_0 < 0.1$ under normal pressure) were detected, despite the very small initial bubble diameter $d_0 = 0.05-0.1$ mm. This absence of slow waves is attributable to an anomalously high compressibility of this two-phase system, causing bubbles to collapse already under a pressure difference of 0.002 MPa. Incomplete relaxation and resulting faster propagation can occur only at pressures under which bubbles do not collapse. The dependence of the velocity of acoustic waves and of shock waves on the volume concentration is also calculated, on the basis of the dispersion equation for nonequilibrium heat and mass transfer in a wave according to a model of the system referred to a single bubble: one part in thermodynamic equilibrium with that bubble and one part not perturbed by thermal interaction with that bubble. Articles was presented by Academician M. A. Sadovskiy on 3 Jun 1983. Figures 3, references 9: 5 Russian, 4 Western.

[6-2415]

UDC 533.6.011.5

DENSITY DISTRIBUTION IN SUPERSONIC JET DISCHARGED INTO VACUUM THROUGH NOZZLE WITH OBLIQUE THROAT

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 6, Nov-Dec 81 (manuscript received 3 Jun 82) pp 179-180

RODIONOV, A. V., Moscow

[Abstract] Three-dimensional flow of a supersonic jet from a horizontal conically diverging nozzle with a throat not perpendicular to its axis is analyzed theoretically, by comparing such a jet with an axisymmetric one flowing from an identical nozzle with a normal throat. Calculations are based on inclusion of a vertical momentum component $J_y = J_x \frac{\tan \psi}{1+K} 2$ (J_x - horizontal

momentum component, $k = c_p/c_v$, M - Mach number at throat edge in the horizontal plane through the nozzle axis, ψ - inclination angle of plane of throat). The difference between both jets is largest in the vertical plane through the nozzle axis at the throat center and smallest in the horizontal plane through the nozzle axis. As angle θ of nozzle divergence increases, the Mach number becomes more nonuniformly distributed over the throat contour. The density distribution ρ_2 in such a three-dimensional jet, relative to the density distribution ρ_1 in the corresponding axisymmetric jet, has been evaluated numerically for $k = 1.15-1.4$, $M = 2.5-5$, $\theta = 0-10^\circ$, $\psi = 0.40^\circ$ on the basis of the relation $\ln(\rho_2/\rho_1) = J_2 f \cos \psi$ with $f = 1.85 \gamma - 0.75 \gamma^2 + 0.1 \gamma^3$ ($\gamma = r/x \sqrt{1-J_1}$, x - axial coordinate, y - vertical coordinate, z - transverse coordinate, $\psi = \tan^{-1} z/y$, $r = y/\sin \psi$). The author thanks Yu. M. Lipnitskiy for interest and helpful comments. Figures 2, references: 5 Russian.

[22-2415]

NUMERICAL SIMULATION OF IMPACT OF SNOW AVALANCHE ALONG SOLID WALL

Moscow IZVESTIY. AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian
No 6, Nov-Dec 83 (manuscript received 24 Sep 81) pp 86-91

GONOR, A. L. and PIL-PICHAK, Ye. G., Moscow

[Abstract] A snow avalanche is treated as an elongated stream of snow mass with some complex velocity distribution, most often of much larger width than height. Such proportions permit representing an avalanche as an infinitely long half-strip which moves uniformly in every plane parallel to its axis and perpendicular to the bed surface. Although this approximation is not valid at the lateral edges, the edge effect is negligible in very wide avalanches. Impact of such an avalanche along a solid wall is analyzed in the hydrodynamic approximation, considering that at the instant of impact the distribution of flow parameters is not uniform. Preliminary studies have revealed that body forces and viscous forces are negligible in comparison with forces of the pressure gradient and inertia forces. Therefore, the model of an ideal compressible fluid is applicable here with a somewhat more complicated equation of state. The corresponding equations of continuity, motion, and energy are formulated in Lagrangian coordinates. The equation of state is approximated as $p = p_0 f(\rho/\rho_0) + c\rho E$ (p - pressure, ρ - density, E - internal energy), just as for many homogeneous and heterogeneous continuous media (water, metals, soil), with function f expanded in a Taylor series with respect to the small parameter $\rho/\rho_0 - 1$ and assuming $(\partial E/\partial T)_\rho = c_v = \text{const}$ (T - temperature). After all unknown quantities had been determined, namely temperature and specific heat as well as the coefficients in the polynomial $f(V_0/V) = d + \alpha(V_0/V - 1) + b(V_0/V - 1)^2$ to which the Taylor series reduces with volume V replacing density ρ , this system of equations was solved numerically by a finite-difference method according to an explicit scheme. A shock wave was simulated by means of a square-law fictitious viscosity for $d\rho/dt > 0$ (zero viscosity for $d\rho/dt \leq 0$) appearing as additional pressure. Figures 5, references: 11 Russian.

[22-2415]

GEOMETRICAL CHARACTERISTICS OF SEPARATION OF TURBULENT BOUNDARY LAYER IN CONICAL STREAM DUE TO INTERACTION WITH FORWARD DENSITY JUMP

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian
No 6, Nov-Dec 83 (manuscript received 16 Aug 82) pp 45-51

ZUBIN, M. A., Moscow, and OSTAPENKO, N. A., Institute of Mechanics, Moscow State University

[Abstract] Separation of a turbulent boundary layer at a delta wing or a plate in a conical stream, caused by a density drop to such a layer as a

result of interaction with a shock wave, is analyzed for the purpose of establishing whether and how the two acute angles φ and γ defining the geometry of the separation region (angles which the separation line and the re-attachment line make with the direction of the unperturbed stream) depend on three parameters: magnitude of the density drop ρ^0 , Mach number of the unperturbed stream M_{∞} , sliding angle ξ of the leading edge of the wing or plate at which separation occurs. An interpretation and evaluation of available experimental data reveals that angles φ and γ depend only on the density drop and on the Mach number but not an angle ξ . Figures 7, references 21: 11 Russian, 10 Western.

[22-2415]

UDC 532.5.011:532.529.5

MODEL OF GAS OF SOLID PARTICLES WITH INELASTIC COLLISIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 6, Nov-Dec 83 (manuscript received 16 Jul 82) pp 12-16

MATVEYEV, S. K., Leningrad

[Abstract] The continuum of randomly moving solid particles is described by the simple model of an ideal nonconducting gas, namely a system of three partial differential equations in density ρ , velocity v , pressure p , and total energy E . The ratio $k = c_p/c_v$ of specific heats in the relation $p = (k-1)\rho U$ between pressure and kinetic energy U of random motion is either $5/3$ or $4/3$ depending on whether random rotation is disregarded or included. In the case of not perfectly elastic particles there occurs an irreversible conversion of kinetic energy U to internal energy. Accordingly, a fourth partial differential equation is added to the model: an equation in internal energy for the intensity of energy conversion. Inelastic collision of two nonrotating particles is considered first. A gas of solid particles uniformly filling a finite space is considered next, its parameters being initially ρ_0, v_0, p_0, U_0 . The variation of pressure and kinetic energy U with time, following inelastic collisions, is calculated for the case of a constant inelasticity coefficient and the case of a velocity-dependent inelasticity coefficient (proportional to velocity below critical velocity and equal to unity at or above critical velocity). Density and velocity remain constant, while the pressure relaxation time is proportional to the particle size and inversely proportional to the particle volume concentration. The interaction of a stream of solid particles with a continuous solid barrier or with another stream of solid particles is calculated on the basis of this model, taking into account that surface discontinuities can occur in the case of not perfectly elastic particles and including the density jump due to sudden insertion of a barrier but disregarding the effect of the carrier medium in which the solid particles move. Figures 2, references: 4 Russian.

[22-2415]

CONSERVATIVE ALGORITHM OF SOLUTION OF BOLTZMANN EQUATION FOR GAS MIXTURE

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOGO FIZIKI in Russian
Vol 23, No 6, Nov-Dec 83 (manuscript received 21 Apr 82) pp 1517-1520

RAYNES, A. A., Leningrad

[Abstract] The system of equations $\frac{\partial f_i}{\partial t} = \frac{1}{2\pi} \sum_{j=1}^{\infty} \sum_{i,j} (f'_i f'_j - f_i f_j) \sigma_{ij} (q_{ij}, k) \sin \theta d\theta d\varphi du_j$ for a binary mixture (f_i - distribution function of i -th component with molecular velocity u_i , σ_{ij} - total cross section for collision, $q_{ij} = q_{ji} = u_j - u_i$, $k = \{\cos \theta, \sin \theta \cos \varphi, \sin \theta \sin \varphi\}$) is solved by the Euler method $f_i(t + \Delta t) = f_i(t) + \Delta t \sum_j l_{ij}$. A conservative algorithm of such a solution is constructed, upon introduction of a fixed grid in the velocity space which is uniform in all variable. The collision integrals l_{ij} are evaluated by the Monte Carlo method, assuming that the five-dimensional random vector has two components (v_i, w_i) with normal distributions and three components (θ, φ, u_i) with uniform distributions over a cube each. The distribution function f_i is corrected on each step by a polynomial $P_i(u_i) = a_{0i} + a_{1i}u_i + a_{2i}v_i + a_{3i}w_i + a_{4i}(u_i^2 + v_i^2 + w_i^2)$ with the number of coefficients equal to the number of independent moments retained during relaxation. Since the number of unknown coefficients is larger than the number of equations, the errors in calculation of density, energy, and momentum are split into partial errors proportionally to respective relative errors and equations are set up for each part. The original system of 10 equations with 10 unknowns is then split into two systems of 5 equations for the coefficients, one system for each mixture component. This algorithm is demonstrated on a test problem of relaxation, uniformly in space, for a methane-argon mixture consisting of solid spherical particles (ratio of masses $m_1/m_2 = 0.401$, ratio of cross section for collision $d_1/d_2 = 1.121$) with given initial conditions. Figures 4, references 3: 2 Russian, 1 Western.

[21-2415]

ACCOUNTING FOR EMISSION IN TWO-DIMENSIONAL PROBLEMS OF RADIATIVE GAS DYNAMICS

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOGO FIZIKI in Russian
Vol 23, No 6, Nov-Dec 83 (manuscript received 12 Apr 82) pp 1512-1517

BABEVA, O. Yu. and CHETVERUSHKIN, B. N., Moscow

[Abstract] A method of solving two-dimensional problems of radiative gas dynamics is described in which the radiant energy flux W and its divergence $\operatorname{div} W$ can be determined more precisely than in the conventional multigroup diffusion approximation. The corresponding system of equations is shown for

a plane-parallel geometry, the four coefficients D_x, D_y, C_x, C_y in these equations being determined from the solution to quasi-one-dimensional (in space) equations for the radiation intensity. An analogous system of equations can be set up for an axisymmetric geometry. A major advantage of this method is that the equations, after reduction to an elliptic equation for the group radiant energy density U^k , do not contain terms with mixed derivatives and with small alternating coefficients D_{xy}^k . An intricate frequency dependence of the absorption coefficient is handled by discretization and subsequent averaging with respect to frequency, and dependence on the angle is handled similarly. The method can be extended to transient problems, in which case one "freezes" the coefficients. The method is demonstrated on a model problem of cooling for a substance occupying a plane-parallel space. The solution by this method is compared with and found to be more efficient than a solution by the quasi-diffusion method with $k=7$ groups. Figures 4, references 8: 7 Russian, 1 Western.

[21-2415]

UDC 517.958:533.7

MOLECULAR-KINETIC DERIVATION OF EQUATIONS OF MULTITEMPERATURE MULTIVELOCITY GAS DYNAMICS AND CONDITIONS FOR THEIR APPLICABILITY

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian
Vol 23, No 6, Nov-Dec 83 (manuscript received 7 Jan 82) pp 1443-1453

GLAKIN, V. S. and MAKASHEV, N. K., Moscow

[Abstract] The solution to the dimensionless Boltzmann equation of gas dynamics, namely the distribution function of f with respect to the Knudsen number Kn , is considered from the standpoint of applicability to binary mixtures of monatomic gases with arbitrary ratio $\xi = (m/M)^{1/2}$ of their molecular masses and particularly in the case of $\xi \ll 1$. The corresponding Boltzmann mutual-collision integrals $J(f,F)$ and $J(F,f)$ are expanded for derivation of a system of kinetic equations, which also include the Boltzmann self-collision integrals $J(f,f)$ and $J(F,F)$, assuming arbitrary concentrations and arbitrary cross sections for collision. The conditions for validity of the gas dynamic description when Kn does not approach zero are established in terms of the critical Knudsen number for a two-temperature two-velocity gas dynamic system. The general equations of gas dynamics for $\xi \ll 1$ are then derived in the Navier-Stokes approximation, with the transfer coefficients described by Sonin polynomials. Figure 1, references: 10 Russian.

[21-2415]

LASERS AND MASERS

NONLINEAR LASER CUTTING OF RNA SELECTIVE WITH RESPECT TO COMBINATION OF SUBSTRATES

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 38, No 9, 10 Nov 83 (manuscript received 6 Aug 83) pp 424-427

BENIMETSKAYA, L. Z., KOZIONOV, A. L., NESTERIKHIN, Yu. Ye., NOVOZHILOV, S. Yu., RAUTIAN, S. G. and STOCKMANN, M. I., Institute of Automation and Electrical Measurements and Novosibirsk Institute of Organic Chemistry, Siberian Department, USSR Academy of Sciences; BULYCHEV, N. V. and LEBEDEV, A. V., Institute of Organic Physics, Siberian Department, USSR Academy of Sciences

[Abstract] The method of two-quantum affine modification has been developed for laser cutting of RNA selectively with respect to the sequence of substrates. Treatment of an RNA segment is facilitated by complementary-tracer modification, which involves chemically adding a reactive cluster to the tracer oligonucleotide with a sequence of substrates complementing the given one and subsequent formation of a Watson-Crick complex by this oligonucleotide and the given RNA segment. A dye molecule is chemically added to such an oligonucleotide for selective photomodification. The method has been proved out experimentally. In a subsequent study was discovered nonlinear laser cutting of RNA selective with respect to combinations of substrates upon addition of a tracer dye. The dye had an R(pT)₉ structure with the radical R containing the chromomorphous dansil group bonded to a phosphorus atom at the 5' end of the (pT)₉ oligonucleotide. This nonlinear laser cutting was tested with an LGI-21 N₂-laser (average power 1.4 mW, pulse power density 70 MW/cm²) and by the standard biochemical method of gel filtration, utilizing the photo-induced diffusion effect (fragments of NA molecules leaving the irradiated region faster than whole NA molecules enter from adjacent regions). Measurements were made at 19°C, with 10 mM tris-HCl (pH= 7.5) + 10 mM MgCl₂ + 0.2 M NaCl as buffer. Analysis of RNA specimens irradiated at a power density of 150 MW/cm² by the gel filtration method has revealed that an increase of the irradiation dose causes a redistribution of poly-A molecules toward smaller sizes but no significant redistribution of RNA without R(pT)₉ tracer. Transfer of excitation from tracer to NA appears to be the universal mechanism of this nonlinear laser cutting. The authors thank D. G. Knorre for principal assistance in formulation of the problem and in the subsequent work, including helpful discussions. Figures 3, references 9: 7 Russian, 2 Western.

[19-2415]

SEMICONDUCTOR LASER ($\lambda = 1.55 \mu\text{m}$) WITH DISTRIBUTED FEEDBACK IN FIRST ORDER PRODUCED BY LASER-PULSE ANNEALING

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 9, No 21, 12 Nov 83 (manuscript received 1 Aug 83) pp 1294-1297

KARPOV, S. Yu., KOVAL'CHUK, Yu. V., KUCHINSKIY, V. I., LAZUTKA, A. S., MAYOROVA, N. I., MISHURNYY, V. A., PORTNOY, Ye. L. and SMIRNITSKIY, V. B., Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] A laser with distributed feedback in the first order was built using the InGaAsP/InP semiconductor system. The feedback was produced by means of laser-interference annealing, the diffraction grating in the active layer was produced by another method (PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI Vol 9, 1983 p 1000). The experimental prototypes are heteroepitaxial structures consisting of a unimodal InGaAsP ($E_g = 0.8 \text{ eV}$) waveguide layer grown on an n-InP ($E_g = 1.35 \text{ eV}$) single crystal as substrate. The diffraction on the polished substrate surface is produced by chemical etching through a photoresist mask which had been produced by exposure, with the appropriate interference pattern, to radiation from an He-Cd laser ($\lambda = 0.4416 \mu\text{m}$). The holographic diffraction grating in the active layer is produced by exposure of the corrugated substrate surface to radiation from an Nd:YAG laser emitting monopulses of nanosecond and pico-second durations. This new semiconductor laser is pumped by an Nd:YAG pulse laser. Its emission wavelength depends linearly on the temperature, the wavelength of spontaneous emission varying from $1.512 \mu\text{m}$ at 95 K to $1.535 \mu\text{m}$ at 150 K and the wavelength of the Bragg line varying only from 1.55 to $1.5550 \mu\text{m}$ over this temperature range. Optical pumping from the side of the corrugated substrate surface rather than from the side of the active layer results in periodic modulation of the concentration of excess charge carriers excited by light. The authors thank S. A. Aleksandrov and O. A. Smol'skoy for assistance in preparation of experimental specimens, and Zh. I. Alferov for helpful discussions. Figures 3, references 5: 4 Russian, 1 Western.

[14-2415]

UDC 535.3

DEPENDENCE OF ECHO SIGNAL KINETICS ON FLUORESCENCE DECAY TIME DURING FAR-RANGE LASER PROBING OF AQUATIC MEDIA

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 271, No 2, Jul 83 (manuscript received 14 Dec 82) pp 344-348

DEMIDOV, A. A. and FADEYEV, V. V., Moscow State University imeni M. V. Lomonosov

[Abstract] The process of echo signal generation by fluorescent impurities during laser-pulse probing of natural waters is analyzed, taking into account the decay of fluorescence. The magnitude of an echo signal as a function of

time is determined from the solution to corresponding transient problems in the theory of radiation energy transfer. The solution is obtained by the operational method and with the aid of a Laplace transformation, a "single component" impurity being considered here for simplicity. In some cases such as Rayleigh or Mie scattering and spontaneous Raman scattering the conversion of laser excitation to echo response can be assumed to occur instantaneously, but not so in the case of fluorescence. Here the conversion time is finite and its length depends on the population kinetics in the excited state of impurity molecules. This is taken into account in determining how the waveform and the amplitude of an echo signal depend on the duration of the laser excitation pulse and on the fluorescence decay time. The simplest case is considered here, namely coaxial probing and a receiver with rectangular entrance aperture. The relation obtained on this basis is useful for determination of the vertical impurity profile from the concentration at depth, also for calculation of the absorption and scattering coefficients from the easily measurable echo signal peak value. The reverse problem, namely determining the fluorescence decay time, can be solved by probing the medium with a certain kind of pulse such as a σ -pulse and measuring the time of which the echo signal reaches its peak value. Article was presented by Academician L. V. Keldysh on 15 November 1982. Figure 1, references: 8 Russian.

[8-2415]

UDC 543.426

DETERMINING NEON MICROCONCENTRATION IN HELIUM DURING LASER EXCITATION OF $2p^53s \rightarrow 2p^53p$ NEON TRANSITION IN HIGH-FREQUENCY DISCHARGE

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 39, No 5, Nov 83
(manuscript received 26 Jul 82) pp 757-762

BOL'SHAKOV, A. A., OSHEMKOV, S. V. and PETROV, A. A.

[Abstract] The problem of lowering the detectability threshold of gases in a mixture during spectral analysis is considered, one method being to use a stronger signal from a dye laser and thus add to the population at the upper level of the analytical line from the most populated lower excited state. In the transillumination mode the populations at these two levels of the "active" transition tend to become equal, differing only statistically, while the fluorescence signal reaches its maximum and ceases to depend on the spectral density of the pumping power. In a feasibility study this method of improving the sensitivity of spectral gas analysis was applied to determination of the neon microconcentration in helium in a high-frequency discharge. The latter was produced in the quartz tube of a 500 W - 1.5 MHz VG-5 generator. Fluorescence was excited by means of a dye laser (cresyl-violet solution in butanol) tunable over the 570-610 nm range of wavelengths and pumped by second-harmonic emission from an LTIPCh-5 YAG-laser operating in the periodic-pulse mode at 12.5 and 25 Hz repetition rates. The "active" transition for laser excitation was the $2p^53s(^3P_2^0) \rightarrow 2p^53p(^3P_1)$ neon transition (wavelength $\lambda = 588.2$ nm), its lower level being the most populated one. A specimen of helium was

admitted to a preevacuated discharge tube under a pressure of 1.7 kPa. After ignition of the discharge, fluorescence signals were measured repeatedly over a certain period of time (160 s) and recorded at the 616.4 nm line of the high-probability $3p_1 \rightarrow 3p_0^0$ transition. After calibration of the measured pressure dependence of the fluorescence signal intensity and extrapolation to the noise level according to the 3σ -criterion, to account for the insufficient purity of helium, the results indicate that the neon detectability threshold can be lowered by this method from $5 \cdot 10^{-4}$ vol.% (in emission spectral analysis) to $1 \cdot 10^{-6}$ vol.%. Plasma hum is the main factor which limits the detectability and must be reduced if the threshold is to be further lowered. Figures 4, references 9: 8 Russian, 1 Western.
[4-2415]

UDC 535.853.31

EXPERIMENTAL STUDY OF POLARIZATION CHARACTERISTICS OF REFLECTIVE DIFFRACTION GRATINGS FOR CO₂-LASERS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 39, No 5, Nov 83
(manuscript received 10 Aug 82) pp 751-757

NEVDAKH, V. V., LESHENYUK, N. S. and ORLOV, L. N.

[Abstract] An experimental study of reflective diffraction gratings for tunable CO₂-lasers was made, for the purpose of determining their polarization characteristics. The radiation source was a tunable stabilized CO₂-laser emitting at separate vibrational-rotational transitions within the two 9.6 μm and 10.6 μm bands, with a power of 1.5 W at the strongest transition. The gratings had 75, 100, and 150 lines/mm respectively, their blaze angle ranging from 17 to 40° and their "active" surface metallized with gold, aluminum, or AMTs aluminum alloy. The reflection coefficients or diffraction efficiency in the zeroth and first spectral orders, in the autocollimation mode, were measured as function of the angle γ between the E-vector of the incident wave and the grating lines. The polarizer and analyzer were two MLR-1 germanium plates oriented at the Brewster angle. Instrumentation included an IMO-2N wattmeter, a wavelength regulator with removable mirror, a shutter, an SPM-2 monochromator, a photoreceiver and an oscilloscope. The results reveal that radiation in both spectral orders is linearly polarized, but only the polarization plane for the first order is rotated in agreement with theoretical prediction ($\tan \psi = \sqrt{R_p/R_s} \tan \gamma$ (R_p, R_s reflection coefficients in directions respectively parallel and perpendicular to the grating lines)). The measured rotation angle of the polarization plane for the zeroth order did not agree with theoretical prediction. A likely cause of this discrepancy is existence of a phase anisotropy for this spectral order in such diffraction gratings. The results of this study indicate that reflective diffraction gratings can be used not only on the side of the "active" (longer) strip edge but also on the side of the shorter strip edge, with the diffraction efficiency being the same for the same incidence angles in each case, also without autocollimation. This is equivalent to rotation of the grating through 180° in the XOY-plane

about the Z-axis, with the diffracted beam in the first order first leaving the X0Y (incidence) plane before at some angle the edges "switch" and then returning to autocollimation at 180°. Figures 1, references 19: 11 Russian, 8 Western.

[4-2415]

UDC 621.373.8

LONGITUDINAL GAIN DISTRIBUTION IN He-Ne LASER CELLS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 39, No 5, Nov 83
(manuscript received 30 Jul 82) pp 744-746

GUDELEV, V. G. and YASINSKIY, V. M.

[Abstract] The longitudinal gain distribution in He-Ne laser cells is examined and causes of its nonuniformity are established. On the basis of experimental studies and measurements, this nonuniformity has been found to be associated with appearance of a variable component in the intensity of lateral spontaneous emission. The frequency of this component decreases as the discharge current increases, which characterizes traveling streaks in a d.c. discharge. Accordingly, the nonuniformity of the longitudinal gain distribution is attributable to the nonuniform amplitude distribution of streaks traveling along the positive column. This is demonstrated by measurements made in a laser cell filled with equisotopic ^{20}Ne : ^{22}Ne : ^3He = 1:1:20 mixture under a total pressure of approximately 400 Pa. Calculations were made using the semi-empirical relation for the gain as function of the longitudinal coordinate and time $G(z,t) \propto I_0 + I_1 \sin \omega t + I_2 e^{\alpha z} \sin(\omega t + kz)$ (I_0 - average intensity of lateral emission, I_1 - alternating component of this emission, I_2 - intensity of traveling and exponentially building up wave, α - streak gain, ω - frequency of discharge current oscillation). Figure 1, references 7: 6 Russian, 1 Western.

[4-2415]

UDC 621.373.535

DEPENDENCE OF SHIFT IN POSITION OF He-Ne LASER BEAM AXIS ON CHANGE IN REFRACTIVE INDEX OF AMBIENT MEDIUM

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 39, No 5, Nov 83
(manuscript received 18 May 82, after completion 13 Jun 83) pp 740-744

ABRAMOV, V. Ya., PIPCHENKO, V. P., KLIMKOV, Yu. M. and PEREBYAKIN, V. A.

[Abstract] The space characteristics of a laser beam are analyzed, specifically the dependence of the position of its axis on the refractive index of the ambient medium. The method of analysis is based on two matrices: the matrix of beam transformation along the path between resonator mirrors and the matrix

of a round trip of the cavity. This method is applied to a capillary beam, equivalent to a beam with a gaussian diaphragm at both ends, produced by a He-Ne laser and a two-mirror resonator with Brewster windows. Calculations based on laws of geometrical optics, assuming a parabolic transverse profile of medium properties in the discharge tube, yield the angular shift of the beam axis at the resonator exit relative to the optical axis of the resonator as function of the ambient pressure before and behind the exit mirror and as function of the outer radius of the exit mirror. The results reveal a possibility of reducing this shift by use of a converging lens as substrate for the exit mirror. Figures 2, references 7: 5 Russian, 2 Western.
[4-2415]

UDC 621.373.826.038.825.3

MAXIMUM ATTAINABLE EFFICIENCY OF HARMONIC EMISSION BY Nd-LASER

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 10, Oct 83 pp 1910-1918

BEGISHEV, I. A., GULAMOV, A. A., YEROFEYEV, Ye. A., REDKORECHEV, V. I. and USMANOV, T., Institute of Electronics imeni U. A. Arifov, UzSSR Academy of Sciences

[Abstract] An experimental study of a neodymium (in phosphate glass) power laser was made for the purpose of determining the maximum attainable efficiency of harmonic emission in pulses of 500 ns duration. The oscillator part of the equipment included a neodymium-activated phosphate-glass laser emitting one longitudinal mode and one transverse mode, a Pockels cell, a three-pass preamplifier, another Pockels cell, a space-frequency filter, an apodized (metal film on glass substrate) diaphragm, and another preamplifier. The amplifier part consisted of three phosphate cells (two 20x270 mm and one 45x630 mm) or four phosphate cells (one 20x270 mm, one 30x270 mm, two 45x315 mm) with a vacuum-type space filter between stages, and two birefringent nonlinear crystals (potassium phosphate monobasic). Energy measurements were made with seven calorimeters, waveform and duration of laser emission pulses were measured with an FK-27 high-speed photodiode and an S7-15 oscilloscope. In the experiment second-harmonic emission, third-harmonic emission, and fourth-harmonic emission were studied. The maximum theoretically attainable 90% efficiency of second-harmonic emission was attained with a 32 mm aperture of the laser beam, but 100% efficiency was also found to be a realistic goal. The maximum theoretically attainable 83% efficiency of third-harmonic emission was approached, 80% being close, by using a hypergaussian laser beam and getting a 3:2 ratio of second-harmonic energy to fundamental-mode energy at the mixer crystal entrance. Fourth-harmonic emission was achieved by conversion of second-harmonic energy at 93% efficiency. Figures 5, table 1, references 10: 5 Russian, 5 Western.
[12-2415]

CALCULATION OF LASER ACTION ON PLANE TARGET AND ITS VAPOR

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian
Vol 23, No 6, Nov-Dec 83 (manuscript received 10 Dec 81) pp 1520-1522

ZUBOV, V. I., KRIVTSOV, V. M., NAUMOVA, I. N. and SHMYGLEVSKIY, Yu. D.,
Moscow

[Abstract] Action of an Nd-laser on an aluminum target is calculated by a numerical algorithm, for a laser beam which propagates through a cylinder of radius R and strikes the target normally. The calculation is based on the equations of spectral energy transmission through space and heat conduction in the target, assuming local thermodynamic equilibrium and evaporation of the target material to saturation through an isothermal jump. The radiation intensity varies in time and the initial condition is a target in an atmosphere of its rarefied cold vapor. Account is taken of reflection of radiation by aluminum condensate and absorption of radiation by aluminum vapor. These calculations yield the evolution of thermodynamic parameters depending on the radius of the incident laser beam. A comparison of the results with those based on the one-dimensional approximation and with the results of an experiment reveals appreciable differences. Evaporation begins later according to calculation by both methods, as indicated by the curves depicting the pressure transient over the irradiated circular spot on the target surface. Figure 1, references: 4 Russian.

[21-2415]

MAGNETOHYDRODYNAMICS

UDC 550.83

FIRST SOVIET-FINNISH EXPERIMENTAL RECORDING OF MHD-GENERATOR SIGNALS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 271, No 2, Jul 83
(manuscript received 14 Mar 83) pp 324-327

VELIKHOV, Ye. P., academician, GORBUNOV, G. I., corresponding member, USSR Academy of Sciences, VOLKOV, Yu. M. (deceased), ZHUKOV, B. P., academician, VAN'YAN, L. L., DEMIDOVA, T. A., ZHAMAETDINOV, A. A., HJELT, S. E. (Finland), and HEIKKA, J. (Finland)

[Abstract] In the "Khibiny" experiment in 1976 the first earth-crust probing of the Kola peninsula was done electromagnetically with an MHD generator, for the purpose of areal geoelectrical cartography of this territory and electrical profiling of the Baltic seaboard down to a depth of 100 km underground. The transmitting MHD generator was installed on the isthmus between a Sredniy Peninsula and the Kola mainland. It was necessary to widen the probing sector at distances from 100 to 500 km from the signal source. Receiving stations were located in Rovaniemi, Ivalo, Karigazniemi, Ivari, Kaamanen and Sodankylä. They picked up MHD signals and "cold" starts, with synchronous recording by voice-frequency carrier telegraphy. The generator was operated in two modes: one with its supply circuit energized by unipolar current pulses of 5-7 s duration and $15 \cdot 10^3$ A amplitude, one with its supply circuit energized from a storage battery by a current of up to 700 A chopped at a frequency of 0.5 or 1 Hz. The equipment included a calibrator, a set of active low-pass and high-pass filters specially built at the Oulu University, a control panel, and a GO-9 oscilloscope. Two horizontal components of the electric field were measured: the latitudinal (relative to the magnetic poles) and the meridional. The data yield also information about the lithosphere and the asthenosphere, their physical and thermal states as well as their material composition. The object of future experiments will be probing Northern Finland with an MHD generator by measuring five components of its electromagnetic field. Figures 4, references: 2 Russian.

[8-2415]

IMPLEMENTATION OF IMPLICIT FINITE-DIFFERENCE SCHEMES BY ITERATION METHODS FOR
TWO-DIMENSIONAL MAGNETOHYDRODYNAMICS

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian
Vol 23, No 6, Nov-Dec 83 (manuscript received 4 Nov 81) pp 1417-1426

ARDELYAN, N. V., Moscow

[Abstract] Numerical solution of the system of three MHD equations in a Euclidean R^3 -space by means of implicit finite-difference schemes is considered with the application of iteration methods. Model problems are used, corresponding to the linear acoustic approximation in the isothermal case, for two-dimensional MHD without dependence on the longitudinal coordinate. Grids are introduced which consist of a finite number of triangular cells, generally irregular, also linear spaces of rank $\alpha = 0, 1, 2$ tensor functions (grid scalars $\alpha = 0$, grid vectors $\alpha = 1$, grid dyads $\alpha = 2$) and grid operators. Difference schemes are constructed on this basis, specially a time grid, in operator form and a general convergence test is developed for iteration methods. The condition for convergence is established, an analog of the Courant condition, and two lemmas are formulated which facilitate solution of the problem by the two-layer method or the equivalent Seidel method. The author thanks A. A. Samarskiy for interest in this study and Yu. P. Popov for helpful discussions. References: 12 Russian.

[21-2415]

DISSOCIATION OF CARBON DIOXIDE IN CAPACITIVE HIGH-FREQUENCY DISCHARGE WITH SPACE-PERIODIC STRUCTURE

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 9, No 21, 12 Nov 83 (manuscript received 15 Jul 83) pp 1284-1287

BRAGIN, V. Ye., MATYUKHIN, V. D. and MURAV'YEV, V. F., Moscow Institute of Engineering Physics

[Abstract] A high-efficiency capacitive gas-discharge chamber for dissociation of carbon dioxide has been developed which operates at a frequency of 13.56 MHz. The distance between the two quartz-coated planar electrode is smaller than their width and gas is injected in the direction of the electric field uniformly over the gap section. With a gas flow rate of 5 l-atm/s under a pressure of 100 torr, it is possible to produce discharge in either of two modes: one which is quasi-uniform over the volume and one with a space-periodic distribution of electron concentration in the direction transverse to the gas flow. In a 9-channel discharge it is possible to dissociate 7% of all entering molecules with a 33% efficiency at the maximum attainable power level. The radial distribution of current density was measured with a magnetic probe, almost all current having been found to flow in a bright channel. The temperature distribution over the gas volume was determined from the emission spectrum of the CN- radical, indicating a temperature of 3500-4500 K at the center with a steep drop toward the channel exit. The radial profile of the dissociation level was measured with a cold miniature probe chilling the gas at a rate of 10^8 K/s. Experimental data and estimates of characteristic times of vibrational excitation, dissociation, VT-relaxation, diffusion, and other processes indicate that CO_2 dissociation occurs upon excitation of vibrational degrees of freedom in molecules as well as by the mechanism of thermal heating. Figures 2, references: 2 Russian.
[14-2415]

ANALYSIS OF ADAPTIVE OPTICAL SYSTEM WITH COMPENSATION OF RANDOM TILTING OF WAVEFRONT

Novosibirsk AVTOMETRIYA in Russian No 5, Sep-Oct 83 (manuscript received 17 Jan 83) pp 72-76

[Article by P. A. Bakut, N. D. Belkin, A. D. Ryakhin, K. N. Sviridov and N. D. Ustinov, Moscow]

[Text] There are at present two approaches to realization of adaptive optical systems. The first approach is based on detection of atmospheric phase distortions of luminous radiation and subsequent correction of them and the second is based on formation of the image definition function and maximization of it during a time less than the time correlation interval of atmospheric fluctuations [1]. The disadvantage of the second approach includes insensitivity of the function of definition to random shifts of the image, which in turn make shaping of it difficult. A two-circuit adaptive system with compensation of the random tilting of the wave front and with subsequent formation of the function of definition is of interest in this regard. An adaptive system with maximization of the function of definition was considered in [1]. An adaptive system with compensation of random tilting of the wave front is analyzed in this paper.

One of the possible methods of estimating the random tilting is to determine the random shift of the center of gravity of the image of the object, caused by a shift of the center of gravity of the image of any point of it. The following expression is valid in this case for a random vector of tilting a of the wave front:

$$a = \int d\mathbf{v} W(\mathbf{v}) \cdot F(\mathbf{v}) \text{grad} \phi(\mathbf{v}) / \int d\mathbf{v} W(\mathbf{v}) \cdot F(\mathbf{v}), \quad (1)$$

where $W(\mathbf{v})$ is the aperture function, $A(\mathbf{v})$ is the random value of the amplitude of the received luminous radiation and $\phi(\mathbf{v})$ is its random phase distortion.

As can be seen from (1), the main cause of random tilting of the wave front is phase fluctuations $\phi(\mathbf{v})$. If one takes into account that the effect of atmospheric amplitude fluctuations is negligible during astronomical observations compared to the effect of phase fluctuations [2], then one can assume that $A(\mathbf{v}) = \text{const}$ and

$$a = S^{-1} \int d\mathbf{v} W(\mathbf{v}) \text{grad} \phi(\mathbf{v}). \quad (2)$$

S is the aperture area. By using the known relation from [3], we find the final expression for the vector a in the form

$$a = S^{-1} \int_{\Gamma} q_n(s) d\eta. \quad (3)$$

where Γ is the boundary of the aperture zone and η is the external normal to it.

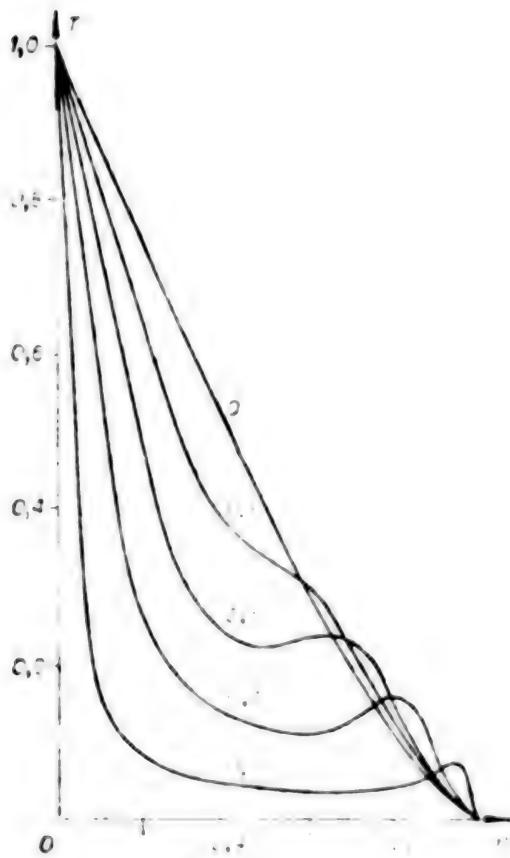


Figure 1

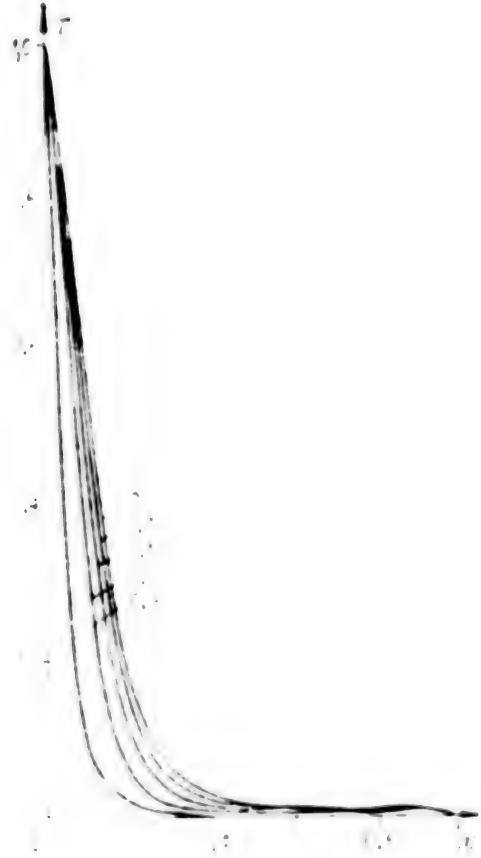


Figure 2

Thus, the adaptively compensated tilting a is linearly dependent on phase fluctuations $q_n(s)$ and its statistical distribution like distribution $q_n(s)$ is gaussian. With this assumption, the mean optical transfer function (OTF) $T(f)$ of the atmosphere-telescope system with adaptive compensation of random tilting is determined by the expression [4]

$$T(f) = T_0(f) \exp \left\{ -\left(\frac{1}{2} [D(x)Lf] - \langle (a/Lf)^2 \rangle \right) \right\}, \quad (4)$$

Here λ is the average wavelength of the received luminous radiation, L is the focal distance of the telescope, $T_0(f)$ is the optical transfer function of the telescope and $D(x) = \langle [q_n(s) - q_n(s+x)]^2 \rangle$ is the phase structural function, which has the form [2, 4]

$$D(x) = 6.88 (|x|/r_0)^{1.7}, \quad (5)$$

r_0 is the spatial correlation radius of atmospheric distortions of the wave front of luminous radiation.

Let us further consider a practically important case--a telescope with annular receiving aperture in which the outer diameter is equal to D and the inner diameter is equal to ϵD . We note that the entire subsequent analysis can easily be carried out for the case of an aperture of arbitrary shape. It is easy to find that

$$\langle (a\lambda L f)^2 \rangle = \frac{6.88}{r_0^{5/3}} \frac{(\lambda L f)^2}{D^{1/3}} S(\epsilon), \quad (6)$$

where

$$S(\epsilon) = \frac{50}{9(1-\epsilon^2)} \int_0^1 T_0(t) t^{2/3} dt. \quad (7)$$

We note that an additional assumption that $[\phi(v)-av]$ is statistically independent of a was made in [4] in derivation of expression (4) for the optical transfer function. This assumption is in fact approximate, but the error is sufficiently small so that it can be taken into account in the first approximation by variation of $S(\epsilon)$ such that $S(0) = 1$. The values of the normalized function $S(\epsilon)$ are presented in the corresponding manner in the table.

ϵ	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
$S(\epsilon)$	1.0000	1.0008	0.9915	0.9801	0.9682	0.9516	0.9305	0.9024	0.8677	0.8251

The mean optical transfer function $T(f)$ of the atmosphere-telescope system is determined without compensation of tilting by the expression [4]

$$T(f) = T_0(f) \exp\left(-\left(1/2\right)D(\lambda L f)\right). \quad (8)$$

It is obvious from comparison of (4) and (8) that a considerable reduction of the effect of the atmosphere, especially discernible in the high space frequency region, is achieved by adaptive compensation of random tilting. The foregoing is illustrated by Figures 1-3, in which the optical transfer functions of the telescope, of the atmosphere-telescope system with adaptive compensation and without it are presented for $\epsilon = 0.0, 0.3, 0.5, 0.7$ and 0.9 at $D/r_0 = 5 [|\mathbf{x}| = \lambda L f / D]$.

The quality of an optical system is traditionally evaluated by its resolution. There are rather many methods of determination of it. Following [4], we use as the measure of resolution of the atmosphere-telescope system the value

$$R = \int df T(f). \quad (9)$$

In essence it determines the correlation quality of the system [5] and is a measure of the direct similarity between the observed object and the shaped image. For an ideal telescope without any distortions, the resolution is



Figure 3

equal to $S/(\lambda L)^2$, i.e., it is inversely proportional to the value of the spatial resolving component of the system. With regard to (4) and (8) for an optical system without compensation for tilting and for a system with adaptive compensation of random tilting of the wave front, we accordingly have values of R_{BK} and R_{AK} , determined by the expressions

$$R_{BK} = 2\pi \left(\frac{D}{\lambda L}\right)^2 \int_0^1 dt t T_0(t) \exp \left\{ -3.44 \left(\frac{D}{r_0}\right)^{5/3} t^{5/3} \right\}, \quad (10)$$

$$R_{AK} = 2\pi \left(\frac{D}{\lambda L}\right)^2 \int_0^1 dt t T_0(t) \exp \left\{ -3.44 \left(\frac{D}{r_0}\right)^{5/3} t^{5/3} [1 - S(\varepsilon) t^{1/3}] \right\}. \quad (11)$$

It is easy to ascertain that there is maximum resolution R_∞ for an infinitely large aperture, determined by the relation

$$R_\infty = \lim_{D, r_0 \rightarrow \infty} R_{BK} = \lim_{D, r_0 \rightarrow \infty} R_{AK} = \frac{\pi}{4} \left(\frac{r_0}{\lambda L}\right)^2. \quad (12)$$

Hence, it is obvious that the atmospheric effect in the case of an infinitely large aperture establishes the same limit of resolution both for systems without compensation for tilting and for systems with adaptive compensation of it. But approximation to this limit in the indicated systems occurs in a considerably different manner, which is indicated by Figures 4 and 5, in which the resolution of the atmosphere-telescope system with and without adaptive compensation is presented. There is a simple monotonic approach of R/R_∞ to 1 in systems without compensation of tilting, while there is maximum resolution in systems with adaptive compensation of the random tilting of the wave front, i.e., there is some optimum value of D/r_0 equal to 3.5 for real values of ϵ at which a fourfold increase of resolution is achieved compared to the former. This result was first found in [4] for a circular aperture. It is interesting to note that the second maximum resolution, which can considerably exceed the first achieved at $D/r_0 = 3.5$, appears for circular apertures with large values of ϵ . The typical value of r_0 for the visible region ($\lambda = 0.5 \mu\text{m}$) is equal to 10 cm, while that for the infrared region ($\lambda = 10.6 \mu\text{m}$) increases up to 4 meters, i.e., it is approximately proportional to $\lambda^{6/5}$. It follows from the derived relation $D^{\text{opt}} = 3.5 r_0$ that the diameter of the receiving aperture of the telescope D must be increased with an increase of the working wavelength λ to realize a maximum advantage in resolution (fourfold) in systems with adaptive compensation of random tilting of the wave front.

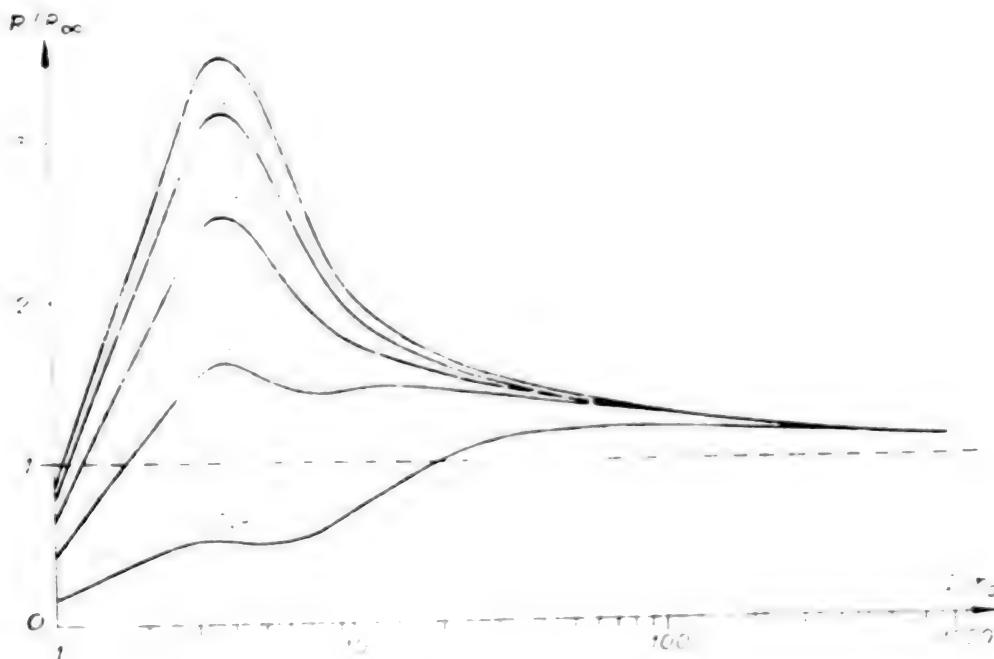


Figure 4

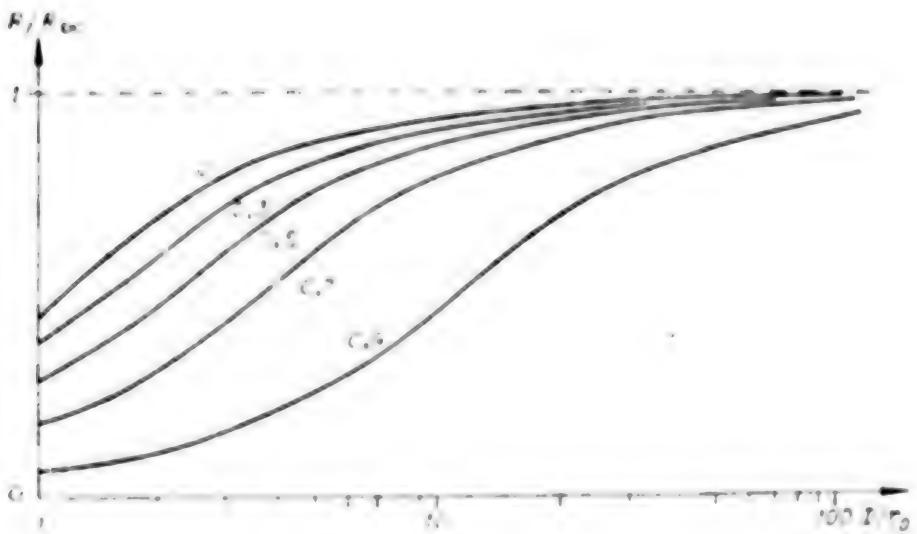


Figure 5

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6521
CSO: 8144/0541

UDC 535.37:546.661:666.22

STRUCTURAL INTERPRETATION OF SPECTRAL LUMINESCENCE CHARACTERISTICS OF
EUROPIUM-DOPED SILICOPHOSPHATE AND GERMANOPHOSPHATE GLASSES

Leningrad FIZIKA I KHIMIYA STEKLA in Russian Vol 9, No 4, Aug 83
(manuscript received 13 Nov 81, after completion 26 Nov 82) pp 487-492

KOLOBKOV, V. P., DUN'KIN, S. P., ZHMYREVA, I. A., KOSHELEVA, Ye. A.,
KUDRYASHOV, P. I. and MOROZOVA, I. N., State Institute of Optics imeni S. I.
Vavilov, Leningrad

[Abstract] A spectroscopic study was made of structural characteristics of silicophosphate and germanophosphate glasses, the main object being to determine the effect of increasing the SiO_2 content (from 20 to 64 mol.%) or the GeO_2 content (from 20 to 80 mol.%) and to track the entry of injected rare-earth activators into the matrix. Infrared spectroscopy and electron-vibration spectroscopy as well as luminescence and Raman scattering were used for measurements and analysis, trivalent europium ($10 \text{ wt. \% } Eu_2O_3$) was used as activator. The results indicate that an increase of the GeO_2 content produces much more appreciable changes in the structure of phosphate glass than does an increase of the SiO_2 content. This is in all probability attributable to the formation of "hybrid" Ge-O-P bonds and to a breakup of the structural lattice of PO_4 -tetrahedra by embedding much larger GeO_4 -tetrahedra but not by embedding SiO_4 -tetrahedra of comparable size. Europium ions become surrounded much more nonuniformly in germanophosphate glass than in silicophosphate glass, the mode of their surrounding being determined basically by the phosphate groups and being most nearly uniform in plain phosphate glass. The presence of GeO_2 or SiO_2 appears to have a relatively small effect on the electron transitions in a rare-earth activator. Figures 3, table 1, references 10: 8 Russian, 2 Western.

[11-2415]

FEASIBILITY OF GENERATING SOLITONS IN MID-INFRARED FIBER OPTICS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 273, No 5, Dec 83
(manuscript received 8 Jun 83) pp 1112-1116

DIANOV, Ye. M., academician PROKHOROV, A. M. and SERKIN, V. N., Institute of General Physics, USSR Academy of Sciences, Moscow

[Abstract] A major achievement in optical long-distance data transmission over nonlinear fiber optics has been generation and propagation of near-infrared pulses. A further breakthrough would be a changeover to the mid-infrared range, in which certain crystalline and amorphous fiber materials offer a much lower power loss (10^{-2} - 10^{-3} dB/km) than quartz glass. Fluoride glasses have been selected as an example of materials suitable for this application. The feasibility and problems of propagating ultrashort pulses through fluoride fiber optics in the soliton mode are examined theoretically, taking into consideration two unfavorable factors. One is that the wavelengths at which the dispersion becomes zero (1.6 - 1.7 μm) do not coincide with the wavelengths at which the optical losses are minimum (3 - 4 μm). The other is the high peak power, proportional to λ^6 , required for generating an infrared soliton. The dynamics of soliton formation, with attendant both linear and nonlinear absorption, are analyzed on the basis of the modified nonlinear Schrödinger equation. Numerical experiments have revealed that the lifetime of bound solitons is determined by linear and nonlinear losses as well as by the frequency sweep rate in the entering pulse. There exists a critical loss level at which the monosoliton state is reached already within one soliton period. Phase modulation in the entering pulse does not inhibit formation of a bound polysoliton state over a wide range of frequency sweep rates, but can appreciably lengthen the period of shape fluctuations of the higher-order solitons. Phase modulation and linear absorption together cause splitting of a bound state into its component solitons. Beginning at some critical frequency sweep rate it becomes impossible to achieve the soliton mode of pulse propagation. An experimental erbium laser ($\lambda = 2.94$ μm) with active mode locking is available as a source of radiation in the $\lambda = 3$ μm band for generating infrared solitons. Figures 2, references 15: 7 Russian, 8 Western.

[7-2415]

UDC 535.373.4

EFFECT OF DEAD TIME IN RECORDING PROCESS ON DETERMINATION OF LUMINESCENCE DECAY BY STATISTICAL METHOD

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 39, No 5, Nov 83
(manuscript received 12 Jul 82) pp 853-855

APANASOVICH, V. V. and CHERNYAVSKIY, A. F.

[Abstract] A simple procedure is proposed for recording luminescence with a multichannel intermittent-duty analyzer and determining the luminescence decay by statistical photon counting. On the premise that the length of dead time remains constant throughout the recording process, this method allows retrieval of the true glow intensity function $\lambda(t)$ from the recorded glow intensity function $b(t)$ in the presence of an interference with intensity $s(t)$. In accordance with the theory of correlated random points and with the aid of generating functionals, a linear relation is established between the true intensity function $\lambda(t)$ and the reciprocal of the probability of single-photon detection. The validity of this method is demonstrated by retrieval of a $\lambda(t) = Ae^{-Bt}$ ($A = 5 \mu\text{s}^{-1}$, $B = 0.6 \mu\text{s}^{-1}$) function in a statistical experiment with a multi-channel intermittent-duty analyzer (dead time $\ell = 0.5 \mu\text{s}$). With $n = 128$ channels, $N = 10,000$ counts in $2 \mu\text{s}$ yielded the glow decay function with an error $\Delta\lambda \approx 0.3 \mu\text{s}^{-1}$. Figure 1, references: 4 Russian.

[4-2415]

UDC 681.7

BILATERAL INTERFERENCE FILTERS FOR FAR-INFRARED REGION OF SPECTRUM

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 39, No 5, Nov 83
(manuscript received 5 Jul 82) pp 805-808

SOGLASNOVA, V. A. and CHERNYAVSKAYA, N. A.

[Abstract] Interference filters for far-infrared diffraction and Fourier spectrophotometers are considered which will effectively stop short-wave radiation from the light source. Experiments were performed with such filters consisting of a capacitive grating on both sides of a polyethylene terephthalate film. The film thickness and the grating period were varied, for correlation with the theory of lossless interference filters and for optimization of the filter performance in 30-1000 μm spectrophotometry. The characteristic impedance and the transmission spectra were measured. The results obtained using filters with a film thickness $s = 12$ or $20 \mu\text{m}$ and a grating period $g = 30$ or $60 \mu\text{m}$, typically, indicate that such filters are eminently suitable for this particular application. Figures 2, references 9: 6 Russian, 3 Western.
[4-2415]

UDC 543.42:621.373.8

ACCOUNTING FOR AND ELIMINATION OF INTERFERENCE IN NONSELECTIVELY SCATTERED RADIATION DURING ATOMIC-FLUORESCENT LASER SPECTROSCOPY (REVIEW)

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 39, No 5, Nov 83
(manuscript received 10 Dec 82) pp 709-725

MATVEYEV, O. I.

[Abstract] Interference in nonselectively scattered laser radiation is a major factor limiting the detectability of atoms during fluorescent spectroscopy. The detectability threshold for any element is determined by a simple relation in the ideal case of signal fluctuation describable by Poisson statistics, but it is much larger in the presence of flicker noise. Interference in nonselectively scattered radiation during resonant fluorescence has been taken into account by various methods, amplitude or frequency (wavelength) modulation being used with continuous-wave dye lasers and nonlinearity of the response of the atomic systems being used in saturation-harmonics spectroscopy with continuous-wave dye or gas lasers. Appearance of a sum signal and generation of a difference signal are used with pulse lasers. Known methods of eliminating interference are shifting the fluorescence line produced during collisional mixing of atomic states in a multilevel atom, sensitization of fluorescence through transfer of excitation energy from one atom to an atom of another kind, producing fluorescence in a magnetic or electric field with utilization of the Zeeman effect or the Stark effect, excitation of high-level states, separating in time the laser excitation and the recording of fluorescence, excitation of atoms at slopes of the Lorentz line, many-photon excitation, and using tunable lasers for fluorescent atoms formed by photodissociation of molecules. Complete elimination of interference has not yet been attained by any of these methods, although it appears to be feasible by their proper modification for any specific element, which stimulates further research and development in ways to maximize the signal-to-noise ratio and to eliminate the residual interference. The author thanks V. I. Balykin for discussion and valuable critical comments. Figures 2, tables 2, references 94: 25 Russian, 69 Western.

[4-2415]

UDC 621.373.826

DIODE LASER SPECTROSCOPY

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 10, Oct 83 pp 2037-2045

KOSICHKIN, Yu. V. and NADEZHDINSKIY, A. I., Institute of General Physics, USSR Academy of Sciences

[Abstract] The feasibility of using semiconductor-diode injection lasers for high-resolution mid-infrared molecular spectroscopy in gas analysis has been

established, such a spectrometer having been developed and tested at the Institute of General Physics using $\text{PbS}_{1-x}\text{Se}_x$ and $\text{Pb}_{1-x}\text{Sn}_x\text{Se}$ lasers built at the Institute of Physics (USSR Academy of Sciences). The spectrometer includes, in addition to such a laser in a cryostat, also a monochromator, two photo-receivers and two Fabry-Perot etalons. Operation of the laser in the periodic-pulse mode maximizes its thermal stability and minimizes thermal frequency detuning, also suppresses interference due to atmospheric turbulence and thus improves the spectrometer sensitivity. The frequency scale was calibrated against the absorption line of $00^{\circ}1-20^{\circ}0$ (P(40)) transition in CO_2 . The resolution was measured on SiF_4 gas containing $^{28}\text{SiF}_4$ under a pressure of 0.2 torr, with NH_3 and CO_2 as reference gases. Errors due to instability of laser frequency tuning and due to temperature drift of optical thickness in a Fabry-Perot etalon were reduced by using an air etalon and a germanium etalon respectively, with simultaneous recording of its spectrum and the sought spectrum. Data processing by correlation methods is most expedient, especially for detection of weak absorption and for analysis of spectra with many overlapping lines. Such a spectrometer can be automated and, with special techniques, used also for saturation spectroscopy, intracavity spectroscopy, two-photon spectroscopy, or double-resonance spectroscopy. Results pertaining to correlation methods of data processing were obtained by the authors with assistance of I. I. Zasavitskiy, P. V. Kryukov, A. N. Perov, Ye. V. Stepanov, A. Yu. Tishchenko, V. U. Khattatov and A. P. Shotov. The authors thank A. M. Prokhorov for formulating the problem of high-sensitivity gas analysis and for support in the study. Figures 5, references 37: 21 Russian, 16 Western.

[12-2415]

UDC 621.391.029.7

NONLINEAR PHENOMENA IN FIBER OPTICS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 10, Oct 83 pp 1951-1954

SOHOR, V. and VARGA, F., Department of Nuclear and Applied Physics, Prague Polytechnic Institute (CSSR), TAM, T. T., Institute of Physics, Hanoi (Vietnam)

[Abstract] The nonlinear phenomenon of stimulated Raman scattering in optical fibers at high levels of energy density corresponding to an input power of the order of 100 mW is analyzed on the basis of classical theory, and from the standpoint of its effect on the data transmission capability of such fibers. The dynamics of stimulated Raman scattering can be described by three nonlinear differential equations for the amplitudes of lattice vibrations X_ω , pumping field intensity E_1 , and signal field intensity E_2 . Because the amplitude of a pumping wave varies (decreases) along an optical fiber rather than remains constant, as it does in a homogeneous nonlinear medium of small thickness, these equations cannot be solved analytically but only numerically. Calculations reveal that generation of Stokes components is delayed in time and their maximum magnitude is correspondingly reached at some distance along

the fiber, that the energy transfer to Stokes components occurs more intensely in fibers with a larger attenuation coefficient, that the attenuation of a pumping wave depends also on the coupling coefficient, and that generation of anti-Stokes components is possible but their detection is much less probable than the detection of Stokes components. These conclusions were verified experimentally, with pumping radiation from a dye Rhodamine-6G laser excited from an N₂-laser (wavelength $\lambda_e = 595$ nm, pulses of 5-8 ns duration and 10 kW power) or with second-harmonic pumping radiation from a synchronized AIG-Nd³⁺ laser (wavelength $\lambda_e = 532$ nm, pulses of 150-300 ns duration and 1.3 MW power). The spectrum of stimulated Raman scattering was recorded with a Zeiss spectrograph on a photographic plate and analyzed with a microphotometer. It was found to depend on both power and duration of the pumping laser pulse in fibers with a ladder profile of the refractive index (IOFAN) but only on the pulse duration in gradient-index fibers (SIECOR). On the basis of these results, taking into account the non-linearity as well as the dispersion characteristics of optical fibers, it has been possible to simulate propagation of soliton pulses and to design glass or quartz fibers accordingly. The authors thank Dr V. Kubecik, Dr I. Ondra and Dr C Andrle for assisting in the studies. Figures 4, references: 5 Western.

[12-2415]

UDC 621.373.826:535.375.56

COHERENT SPECTROSCOPY OF HIGH VIBRATIONAL STATES IN POLYATOMIC MOLECULES. SPECTRAL CHARACTERISTICS OF QUASI-CONTINUUM

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 10, Oct 83 pp 1931-1939

AMBARTSUMYAN, R. B., AKHMANOV, S. A., GLADKOV, S. M., ZADKOV, V. N., YEVSEYEV, A. V., KARIMOV, M. G., KOROTEYEV and PURETSKIY, A. A., Moscow State University imeni M. V. Lomonosov, and Institute of Spectroscopy, USSR Academy of Sciences

[Abstract] A study was made concerning the nonlinear optical susceptibility of vibrationally excited polyatomic molecules. In the experimental part vibrational states in SF₆ gas molecules under a pressure of 2-10 torr were excited via a many-photon process by selective (resonant) infrared radiation from a TEA CO₂-laser in pulses of 150 ns duration and up to 0.5 J energy in the $\sim \omega$ -mode at 947.7 cm⁻¹ frequency. Measurements were made by coherent active Raman spectroscopy with second-harmonic probing radiation from a YAG-Nd laser ($\lambda_1 = 532$ nm) and from a dye laser ($\lambda_2 = 555$ nm) in pulses of 20 ns duration. An IVK-2 computer complex was used for experimental control and data processing. In the theoretical part calculations were made on the basis of the harmonic-oscillator model, the intensity of radiation coherently scattered into the anti-Stokes region being determined by the cubically nonlinear susceptibility of the medium. The susceptibility of SF₆ gas was calculated by direct summation of individual susceptibilities of molecules existing in various quantum states. On this basis the authors determined the effect of uniform width of vibrational transitions and of uniform widening of vibrational states on the Raman scattering spectra of hot SF₆ gas in the region of the

vibrational quasi-continuum, assuming that the width of transition $P_v(E_v)$ is 0.2 cm^{-1} and does not depend on $\{v\}$. The procedure is extended to thermally heated and excited SF_6 gas, based on coherent active Raman spectroscopy in the A_1 -mode at various temperatures. The authors thank A. M. Brodnikovskiy, V. D. Lysov and A. N. Mezentsev for assisting with the experiment and V. N. Bagratashvili, A. A. Makarov and Ye. A. Ryabov for discussing the results. Figures 5, references 12: 6 Russian, 6 Western.

[12-2415]

UDC 621.391.029.7

NONLINEAR PHENOMENA IN FIBER OPTICS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 47, No 10, Oct 83 pp 1874-1879

PROKHOROV, A. M., Institute of General Physics, USSR Academy of Sciences

[Abstract] A major problem in data transmission over optical fibers is widening of the light pulse during its propagation, which limits the transmittable data volume. This pulse widening is caused by intramodel dispersion (frequency dependence of group velocity) and by material dispersion (frequency dependence of refractive index) as well as by differences between the velocities of individual modes in multimode fibers, all these factors making the group velocity frequency-dependent. Underlying nonlinear phenomena, particularly noticeable in fibers with cores made of quartz glass, are: cubic polarization of the electric field in the isotropic core material; stimulated Raman scattering, with the first Stokes component appearing already at low pumping power levels; stimulated Brillouin scattering at low pumping power levels, with the width of the pumping spectrum comparable with the width of the scattering spectrum; four-photon mixing in single-mode and multimode fibers at high pumping power levels, with two quanta splitting into "Stokes" and "anti-Stokes" components; and phase self-modulation of light pulses in a material with refractive index dependent on the light intensity. The effects of dispersion on the transmission capability of optical fibers can be reduced in two ways, either by operating in the frequency range in which material dispersion and waveguide dispersion compensate one another so that the resultant dispersion is minimized, or by utilizing the phase self-modulation for pulse propagation in the soliton mode without changes or with periodic changes of the waveform. Successful solution of the dispersion problems should make it feasible to transmit optical data over distances of hundreds of kilometers along fibers without intermediate repeater stages. References 22: 11 Russian, 11 Western.

[12-2415]

FORMATION OF SUPERSTRONG SHOCK WAVES BY HOT PLASMA PLUNGER

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 38, No 9, 10 Nov 83 (manuscript received 19 Jul 83) pp 421-424

ZOREV, N. N., SKLIZKOV, G. V. and SHIKANOV, A. S., Institute of Physics imeni
P. N. Lebedev, USSR Academy of Sciences

[Abstract] The initial stage of propagation of spherical shock waves, after their formation in a residual gas by a plunger of hot plasma, has so far been studied theoretically only and described by the $D_0 = \alpha T_1^{1/2}$ relation between constant velocity D_0 of the shock wave and ion temperature T_1 of the plasma (coefficient α having different values according to different authors). This relation is based on instantaneous heating of the target and, consequently, on a plasma initially at standstill. In reality a plasma begins to move already during heating by a nanosecond laser pulse so that $T_i = T_s = (E_T + E_K)(\gamma - 1)/Nk$ (E_T - thermal energy, E - kinetic energy, k - Boltzmann constant, N - total number of particles). A subsequent experiment has revealed that not all the energy of a laser plasma can be converted to energy of the shock wave. Accordingly, with the number of particles changing only slightly even when the energy loss is high and with the ratio of thermal energy to kinetic energy changing only slightly (and usually known) under changing conditions, the velocity-temperature relation must be modified to $D_0 = \alpha (\rho T_s)^{1/2}$ and can be used for measuring the ion temperature of a plasma. The experiment was performed with the "Kal'mar" power laser ($E_L \approx 250$ J, $q_0 \approx 2 \cdot 10^{14}$ W/cm²), shock waves being generated in deuterium gas or air and measurements being made by the schlieren-image method. A transition from the initial stage to the next mode of shock wave propagation was found to occur when the plasma pressure at the target became comparable with the plasma pressure behind the wavefront. Theoretical analysis indicates and experimental data confirm that the mass m_0 of evaporated plasma and the coefficient α can be determined, within 10% relative accuracy (absolute error within 30%), according to the relation $m_0 = (\gamma - 1) \rho_1 \alpha^2 \frac{m}{(Z+1)} R_{00}^3$ (R_{00} - radius of the shock wave at the point of transition, ρ_1 - density of the gas). Figures 3, references 7: 4 Russian, 3 Western.

[19-2415]

STRESS, STRAIN AND DEFORMATION

UDC 535.21/621.9.048

DESTRUCTION OF METALS DURING LASER-OPTICAL BREAKDOWN AT METAL-LIQUID INTERFACE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 273, No 6, Dec 83
(manuscript received 28 Jun 83) pp 1364-1367

ARUTYUNYAN, R. V., BARANOV, V. Yu., BOL'SHOV, L. A., academician VELIKHOV, Ye. P., ISAKOV, I. M., KOVALEVICH, A. M., LEONOV, A. G., NOVOBRANTSEV, I. V., PIS'MENNYY, V. D., SMAKOVSKIY, Yu. B. and STEPANOV, Yu. Yu., Moscow Institute of Engineering Physics, Dolgoprudnyy (Moscow Oblast)

[Abstract] Destruction of metals in a transparent liquid medium such as water under laser action is analyzed, assuming conditions of optical breakdown near the metal-liquid interface. The plasma, which during a laser pulse expands beyond the focal spot, is treated as an ideal gas. Pressure and energy relations are established to describe melting and solidification processes within time intervals comparable with the duration of the laser pulse. In the experimental part of the study two XeCl pulse-periodic electric-discharge excimer lasers were used, one with ultraviolet preionization for generating pulses of 50 ns duration and one with electron-beam excitation for generating pulses of 0.5 μ s duration. Specimens of various metals were treated in air and under water. The deepening of craters and caverns per laser pulse was measured and calculated as a function of the number of successive pulses and as a function of the pulse power density in both cases. Here the results for aluminum are shown. They indicate that laser action on the metal is more effective under water than in air and that its effectiveness under water increases after optical breakdown has occurred at the metal=liquid interface, plastic deformation of the metal playing a major role next to evaporation and outflow of the melt. Figures 3, references 11: 6 Russian, 5 Western.

[6-2415]

TORSION OF ELASTIC BEAM OF CIRCULAR CROSS SECTION WEAKENED BY ARBITRARY NUMBER OF SURFACING RADIAL CRACKS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 271, No 2, Jul 83
(manuscript received 13 Sep 82) pp 319-323

ZIL'BERGLEYT, A. S. and SUSLOVA, I. B., Institute of Engineering Physics imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] Torsion of a circular elastic beam with an arbitrary number of surfacing radial cracks is described by the corresponding two-dimensional Prandtl function in polar coordinates which satisfies the constraint of finite energy. A subsequent Abel transformation yields an integral equation of the second kind, which is solved by the method of asymptotic expansion in uniformly converging power series. The torsional stiffness of the beam is defined as a double integral of the Prandtl function and is normalized to that of a crackless beam. The stress intensity coefficient at the tip of a crack, relating the Prandtl function to the shear stress, and the torsional stiffness are both evaluated asymptotically. The results reveal that the stress intensity coefficient is lower in the case of several small closely spaced cracks, because of their interaction, than in the case of a single crack. Article was presented by academician V. V. Novozhilov on 13 September 1982.

Figure 1, references 7: 6 Russian, 1 Western.

[8-2415]

THEORETICAL PHYSICS

VALUES OF DIMENSIONAL QUANTITIES IN QUANTUM CHROMODYNAMICS CALCULATED BY MONTE CARLO METHOD

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 38, No 8, 25 Oct 83 (manuscript received 18 Jul 83) pp 403-406

MAKEYENKO, Yu. M. and POLIKARPOV, M. I., Institute of Theoretical and Experimental Physics

[Abstract] Nonperturbational calculations in quantum chromodynamics by the Monte Carlo method yield dimensional quantities such as the Λ -parameter, all those with the dimension of mass being proportional to $\Lambda_L = \frac{1}{a} \frac{(16\pi)^2}{11g_0^2} \frac{51/121}{11g_0^2}$ (disregarding the polarization of vacuum by quarks). Their special kind of dependence on the constant g_0^2 is the criterion for their values having any relation to continuum theory. For estimating the contribution of higher-order g_0^2 -terms to Λ_L in the specific case of the string tension coefficient, a hybrid grid action S in the β, β phase plane is considered for the calibrating $SU(3)$ group and the expression describing Λ_L is refined to

$$\Lambda_L = \frac{1}{a} \frac{(16\pi)^2}{11g^2} e^{-8\pi^2/11g + 10\pi^2/9} g^{2L/9}$$

This expression yields a higher value for Λ_{MOM} (Λ at the instant of regularization), but a value for the decontainment temperature which does not differ significantly from the one obtained previously. The authors thank R. Petronzio for informing about his study (CERN Preprint TH 3596, 1983) prior to its publication, and J. Kogut, N. Crist, M. Kreutz and A. Mueller for discussions during Soviet-American conference on calibration theories in Yerevan. Figures 2, references: 8 Western.

[17-2415]

SCATTERING OF SOUND BY NUCLEI

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 25, No 11, Nov 83
 (manuscript received 28 Jun 83) pp 3502-3503

GLADKOV, S. O., Institute of Chemical Physics, USSR Academy of Sciences, Moscow

[Abstract] For an evaluation of sound absorption by nuclear spin waves in magnetic and antiferromagnetic materials at ultralow temperatures ($T \ll \omega_{\text{NMR}}$), the sound absorption coefficient at high frequencies ($\omega \gg 1\tau$, τ - relaxation time in antiferromagnetic material when $\omega_{e2}^2 \gg \omega_{\text{TO}}^2 \gg \omega_{e1}^2$) is calculated from the standpoint of an "artificial" thermodynamic equilibrium. The expression for the absorption coefficient is derived by standard procedure, from the collision integral for the merger of two nuclear spin waves into a phonon (or split of a phonon into two nuclear spin waves), taking into consideration that the low-frequency branch of the NSW spectrum is in this case almost linear. That establishes the order of magnitude and the asymptotic trends of the absorption coefficient. Further calculations reveal two peaks not far apart on the absorption curve. The author thanks M. I. Kaganov for helpful discussion and suggestions. References: 3 Russian.

[5-2415]

METHOD OF CALCULATING STEADY MOTION OF RELATIVISTIC ELECTRON BEAMS IN COAXIAL VACUUM LINES

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 23, No 6, Nov-Dec 83 (manuscript received 7 Dec 81) pp 1427-1442

GOLOVIN, G. T., Moscow

[Abstract] A coaxial line is considered which consists of two axisymmetric electrodes, the inner one a cathode and the outer one an anode, with vacuum between them. Each electrode can consist of cylindrical, conical, spherical, or flat segments. Through this line propagates a relativistic electron beam, moving from the acceleration zone under a potential difference of 0.1-0.3 MV to a hypothetical emission zone where the electric field intensity without space charge exceeds the critical level of 150-250 kV/cm. This hypothetical emission zone cannot be wider but can be as wide as or narrower than the actual emission zone. During the transient period of $10^{-9} - 10^{-8}$ s the plasma has no time to build up on both electrodes and to thus decrease the effective interelectrode gap width. Therefore, the effect of plasma motion on the electron beam is disregarded. Solution of the corresponding self-consistent system of steady-state equations (in cylindrical coordinates) yields the characteristics of steady motion of the electron beam, namely: self-consistent electromagnetic fields, trajectories of particles, width of the

emission zone and density of the emission current at the cathode. The system of equations is solved numerically in five steps. First the electric field potential is determined from the partial differential Poisson equation, through approximation of the latter with a finite-difference analog and a boundary condition of second-order accuracy on a nonuniform grid made denser near step singularities and corner points. Then the trajectories are determined from the three ordinary differential equations, by the approximate method used for solving the Vlasov equation of kinetics. Then the space charge density and the current density are determined as functions of the coordinates, this being an ill-conditioned problem not solvable with satisfactory accuracy by the method of macroparticles nor 'v spreading them. Then the width of the actual emission zone and the density of the emission current are determined, upon replacement of the boundary condition with a Fredholm integral equation of the first kind which leads to a system of algebraic equations no matter how it has been approximated. Then the equations describing the self-consistent steady state are integrated by an iteration method. According to the results obtained here, in cylindrical coaxial vacuum lines it is not possible to produce a very thin electron beam at the anode by either narrowing the interelectrode gap or increasing the potential difference across it. At best the beam radius at the anode will be slightly smaller than the beam radius at the cathode. For better focusing, therefore, one uses conical lines. The results of calculations also confirm the results of physical experiments pertaining to the maximum current in a cylindrical line, namely that it first increases with increasing length of the line but beyond some critical length it does not increase further. This makes it easy to calculate the maximum current by the given method, requiring only that the emission zone be stepwise widened until no further increase of the current results. The author thanks A. A. Samarskiy for formulating the problem, for his steady interest in the study over a long period of time, and for his assistance in every area, also V. P. Smirnov, A. V. Gordeyev, V. D. Korolev and Yu. I. Mokin for many discussions of the results. Figures 7, references 20: 19 Russian, 1 Western.
[21-2415]

UDC 517.958:535.4

VALIDATION OF METHOD OF SEMI-INVOLUTION FOR MATRIX OPERATORS IN WAVE DIFFRACTION PROBLEMS

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian
Vol 23, No 6, Nov-Dec 83 (manuscript received 7 Dec 81) pp 1381-1391

SIRENKO, Yu. K., Kharkov

[Abstract] Semi-inversion of matrix operators during regularization of a problem is applied to wave diffraction problems with boundary conditions of the third kind (impedance). The validity of this method is demonstrated by reduction of the corresponding Maxwell equations to two-dimensional Helmholtz equations, after separation of the polarizations and subdivision of the geometry into partial regular regions. This reduces the diffraction problem

to a system of operator equations of the first kind for infinite sequences of unknown coefficients in the series expansion of the field function in these Helmholtz equations. For illustration the author considers diffraction of plane E-polarized waves by a periodic array of ideally conducting half-planes. Each operator equation is rewritten accordingly so as to be reduced to an equivalent operator equation of the second kind $y + R_1 D_1 + [P R_2 D_2 P_3 D_3] y = t$ (y - vector of unknowns R_j - scattering operators, D_j - completely continuous operators in case of interaction between corresponding elementary inhomogeneities through a region with a regular segment or unit operators in case of no interaction; operator P and right-hand side t obtained by solution of preceding operator equation), upon introduction of appropriate meromorphic functions. The validity of the results is proved in two ways, first for a unit operator $D_1 = E$ with consequently an $E + R_1 + V$ operator in the equation (V - completely continuous operator) and then for $D_1 = E$ operators in the second term on the left-hand side. The proof also demonstrates that the method of reduction is convergent with respect to the norm of the Hilbert sequence space. The author thanks A. S. Il'inskiy, A. A. Kirilenko and S. A. Masalov for pointing out the need for this study as well as for their valuable comments and suggestions. Figures 2, references: 15 Russian.

[21-2415]

THERMODYNAMICS

UDC 533.6.011.6:536.24

MODEL STUDY OF HEAT TRANSFER IN SUBSONIC JETS OF INDUCTION PLASMATRON

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian
No 6, Nov-Dec 83 (manuscript received 1 Jul 82) pp 129-135

GORDEYEV, A. N., KOLESNIKOV, A. F. and YAKUSHIN, M. I., Moscow

[Abstract] Flow and heat transfer in subsonic jets of dissociated air were studied experimentally in a model of an induction plasmatron. Both inductor and discharge channel were placed in a high-temperature gas-dynamic chamber. Tests were performed over a wide range of pressure ($p = 5.1 \cdot 10^3 - 1 \cdot 10^5 \text{ N/m}^2$) and corresponding range of velocity ($V = 400-30 \text{ m/s}$) at the channel axis, with constant air flow rate ($Q = 2.8 \text{ g/s}$) and constant high-frequency output power. The input power could be varied smoothly over the 22-45 kW range, atmospheric pressure was maintained in the chamber at low pressure inside the discharge channel. The population temperature of energy levels in oxygen and nitrogen atoms was measured by the spectral method of relative line intensities with a model 2051 McPherson instrument, self-absorption being negligible at atmospheric and lower pressures. Radial and axial temperature profiles were determined microphotometrically from spectrograms obtained with a Dove prism and numerically from the solution to the corresponding Abel integral equation obtained by the Pierce method with iterations, using tables of O_2 and N_2 concentrations. From the temperature data the enthalpy in the jet core was estimated, the jet diameter being $D = 0.025-0.04 \text{ m}$. Heat transfer was evaluated by measurement of the thermal flux with copper-tungsten-quartz continuous-flow calorimeters and by numerical solution of the Navier-Stokes equations in ξ (vortex), ψ (flow function) variables for flow of a compressible viscous heat-conducting gas past a cylinder with flat base (radius $R = 0.015 \text{ m}$, Reynolds number $Re \sim 10^2$). The sought pressure dependence of the thermal flux has been determined from the results, considering that the pressure dependence of the temperature is weak, and also a relation for the heat transfer coefficient at the stagnation point in terms of jet parameters has been established. The authors thank Yu. K. Rulev and V. M. Mysova for assisting with the experiment. Figures 6, references 15: 12 Russian, 3 Western.

[22-2415]

MATHEMATICS

UDC 519.2

MINIMIZATION OF LOSS PROBABILITY IN SYSTEM WITH TWO SERVERS OPERATING AT DIFFERENT EFFICIENCIES

Baku IZVESTIYA AKADEMII NAUK AZERBAYDZANSKOY SSR: SERIYA FIZIKO-TEKHNICHESKIKH I MATEMATICHESKIKH NAUK in Russian Vol 4, No 2, 1983 (manuscript received 21 Jun 82) pp 130-135

SHAKHBAZOV, A. A., Institute of Cybernetics

[Abstract] A problem in queuing theory is solved, namely minimization of the loss probability in the case of two servers operating in a system at different efficiencies when a unit-intensity Poisson stream customers appears at the system input. Each customer finds both servers idle and occupies one according to some rule, or finds only one server idle and occupies it, or finds both servers busy and leaves the system. The problem is to determine the rule of occupancy, when both servers are idle, which will minimize the probability of customer loss thereafter during steady operation of the system. The problem is solved with the aid of a limit theorem for an ergodic process. Proof of the theorem and two corollaries lead to a rule which establishes a definite sequence of occupancy taking into account the ordering or ranking of the two servers. In the special case of equally efficient servers the probability of customer loss will be minimized by a rule of equiprobable occupancy. The optimum ordering of unequally efficient servers depends neither on the form of their holding time distribution function nor on the rate of customer arrival but only on the mean holding time. References 7: 5 Russian, 2 Western.

[23-2415]

UDC 517.43+519.46

NATURE OF r-MATRIX

Moscow FUNKTIONAL'NYY ANALIZ I YEGO PRILOZHENIYA in Russian Vol 17, No 4, Oct-Dec 83 (manuscript received 15 Apr 83, after revision 16 May 83) pp 17-33

SEMENOV-TYAN-SHANSKIY, M. A., Institute of Mathematics imeni V. A. Steklov, USSR Academy of Sciences, Leningrad branch

[Abstract] The concept of an r-matrix is introduced by way of translating its tensor notation into the language of Lie algebras with dual spaces. A

theorem, the Kostant-Adler theorem, is proved for an equation of motion given in terms of a hamiltonian invariant with respect to two Lie-Poisson brackets in the dual space of a Lie algebra. The relation to standard formalism is examined with the aid of two applicable postulates and definition of congruent Lie brackets. Next the Jacobi identity for a Lie bracket and its relation to the Young-Baxter equality are examined with the aid of two applicable postulates and definition of modified Young-Baxter equalities, paradoxically none of these equalities underlying the r -matrix method being ever rigorously satisfied. There follows the factorization theorem based on two preliminary postulates and then quadratic Poisson brackets, for which two postulates are stated and three theorems are proved. A further application is two-dimensionalization, namely extension to integrable nonlinear equations for functions of two variables representable in zero-curvature form, for which four postulates are stated. Finally r -matrices for finite-dimensional semisimple Lie algebras are classified on the basis of six postulates and definition of a graduated operator. References 22: 15 Russian, 7 Western.
[20-2415]

UDC 519

ESTIMATES OF MAXIMUM-LIKELIHOOD KIND FOR NONPARAMETRIC REGRESSION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 273, No 6, Dec 83
(manuscript received 10 Mar 83) pp 1310-1313

NEMIROVSKIY, A. S., POLYAK, B. T. and TSYBAKOV, A. B., Institute of Problem in Information Transmission, USSR Academy of Sciences, Moscow

[Abstract] The problem under consideration is to reconstruct a function $f: X \rightarrow \mathbb{R}^1$ on the basis of its measurement at n points, when the readings have errors $y_i = f(x_i) + \xi_i$ ($i = 1, a, \dots, n$) where ξ_i are independent identically distributed random quantities. A function $f_n = \arg \min_{f \in \mathcal{F}} \sum_i F(y_i - f(x_i))$ in some class \mathcal{F} of functions is proposed as estimate, which becomes a maximum-likelihood one when ξ_i has the probability density p and $F(y) = -\ln p(y)$. Difficulties associated with stipulation of constants in the description of class \mathcal{F} are overcome on the basis of an existence theorem and five additional theorems, two with corollaries, about the solution to the problem. The estimator function F is assumed to be convex and polynomial splines are established as solutions. These theorems establish the convergence and the bounds of such estimates. Article was presented by academician L. V. Kantorovich on 2 March 1983. References 11: 6 Russian, 5 Western.
[6-2415]

GRAPHICAL CRITERIA OF ABSOLUTE STABILITY AND ABSOLUTE INSTABILITY FOR NON-LINEAR CONTROL SYSTEMS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 271, No 2, Jul 83
 (manuscript received 27 Sep 82) pp 307-310

YAKUBOVICH, V. A., Leningrad State University imeni A. A. Zhdanov

[Abstract] A graphical criterion of absolute stability and absolute instability is established for a typical control system describable by the equation $\frac{dx}{dt} = Ax + b\zeta$ ($\sigma = c^*x$ and $\zeta = \varphi(\sigma)$, $\varphi(\sigma)$ being a differentiable function such that $\mu_1 \leq \varphi'(z) \leq \mu_2$ and $\varphi(0) = 0$). This criterion is derived from the A. A. Voronov criterion, after the latter has been formulated as a theorem about location of the hodograph in the complex plane. Three subsequent theorems concerning the consequences of this one establish that the graphical criterion is simpler and somewhat broader than the analytical one. Article was presented by academician V. V. Voronov on 27 December 1982. Figures 2, references 14: 8 Russian, 6 Western.

[8-2415]

UDC 510.644+512.58+517.982

SOME CATEGORIES AND FUNCTORS IN BOOLEAN-VALUED ANALYSIS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 271, No 2, Jul 83
 (manuscript received 22 Nov 82) pp 283-286

KUSRAYEV, A. G., Institute of Mathematics, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] Basic categories \mathcal{U} , $\mathcal{U}^*(B)$ and $\mathcal{P}\mathcal{U}^*(B)$ in Boolean-valued models (B - complete Boolean algebra) are defined in terms of four classes, three universa $Ob\mathcal{U}$, $Ob\mathcal{U}^*(B)$, $Ob\mathcal{P}\mathcal{U}^*(B)$ and class $Mor\mathcal{U}$, whereupon functorial relations between any two classes are examined systematically in the Eilenberg-MacLeyn sense. Five theorems are proved pertaining to the descent functor and the Solovay-Tennenbaum functor for a complete subcategory $C\mathcal{P}\mathcal{U}^*(B)$ of category $\mathcal{P}\mathcal{U}^*(B)$ consisting of cyclic subsets, two of these theorems pertaining to categories whose objects are Banach-Kantorovich spaces and whose morphisms are vector-norm compressing linear operators. Article was presented by academician S. L. Sobolev on 22 Oct 1982. References 14: 11 Russian, 3 Western.

[8-2415]

CONVERGENCE OF ROTHE SCHEME FOR NONLINEAR EVOLUTIONARY EQUATIONS WITH SINGULARITIES

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian
Vol 23, No 6, Nov-Dec 83 (manuscript received 29 Dec 82) pp 1370-1380

TIKHOMIROVA, Ye. I., Moscow

[Abstract] The quasi-linear parabolic equation $\frac{\partial u}{\partial t} = A(x, t, u, \frac{\partial u}{\partial x}, \frac{\partial^2 u}{\partial x^2}) + \frac{1}{x} B(x, t, u, \frac{\partial u}{\partial x}) + C(x, t, u, \frac{\partial u}{\partial x})$ ($0 \leq x \leq 1, 0 \leq t \leq 1$) with a regular singularity in the lowest-order term and with $u(x, 0) = f(x)$, $\frac{\partial u}{\partial x} + g(t, u) = 0$ at $x = 1$ is solved approximately by means of the Rothe finite-difference scheme. The solution $u(x, t)$ is assumed to be sufficiently smooth and confined with the $\{0 \leq x \leq 1, 0 \leq t \leq 1\}$ rectangle. Functions $A(x, t, u, p)$, $B(x, t, u, p)$, $C(x, t, u, p)$ and their low-order derivatives are bounded within some vicinity G on the solution diagram, with $A(x, t, u, p) \geq a_* > 0$ and $B(0, t, u, p) \geq b_* > 0$ within this vicinity G . The convergence of this finite-difference scheme is tested for the auxiliary problem $q(x)y''(x) + x^{-1}p(x)y'(x) + r(x)y(x) = m(x)$ with boundary conditions $y(x) = 0(1)$, $y'(x) = 0(1)$ at $x \rightarrow 0$ and $y'(x) = \alpha_1 y(x) + \beta_1$ at $x = 1$ ($\alpha_1 \leq 0$, $p(0) > 0$, $q(x) \geq 0$, $r(x) \leq c_* < 0$), with functions $q(x)$, $p(x)$, $r(x)$, $m(x)$ assumed to be sufficiently smooth. Four theorems and a corollary are proved concerning the solvability of this auxiliary problem, after it has been transformed into a system of two first-order linear ordinary differential equations and put in matrix form. The results facilitate testing the convergence of this scheme for the original problem and lead to an additional convergence theorem. Equations of the class considered here are found in the study of hydrodynamics. The author thanks A. A. Abramov for steady interest and valuable suggestions, also Yu. I. Mokin for helpful comments. References: 10 Russian.

[21-2415]

CONDITIONS FOR NONEXISTENCE 'IN THE LARGE' AND FOR LOCALIZATION OF SOLUTIONS OF CAUCHY PROBLEM FOR ONE CLASS OF NONLINEAR PARABOLIC EQUATIONS

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian
Vol 23, No 6, Nov-Dec 83 (manuscript received 30 Nov 81, after revision
23 Jun 83) pp 1341-1354

GALAKTINOV, V. A., Moscow

[Abstract] The solution $u(t, s)$ of the Cauchy problem for a nonlinear parabolic equation $Au + u_t - (|u_x|^\sigma u_x)_x - u^\beta = 0$ (time coordinate $t > 0$, space coordinate $x \in \mathbb{R}^1$, σ and β fixed constants) with the initial condition $u(0, x) = u_0(x) \geq 0$ ($u_0 \in C(\mathbb{R}^1)$, $\sup u_0 < \infty$) is analyzed for existence and nonexistence. On the

basis of three auxiliary theorems and a lemma, with the initial function u_0 defined as critical if $u_t(t, x) \geq 0$, the author finds sufficient conditions for non-existence of unbounded solutions, for existence of global solutions when $\beta > 2\sigma + 3$, and for localization of unbounded solutions "in the small" respectively. The results are extended to a multidimensional analog $A(u) = u_t - B(u) - u^\beta = 0$ ($t > 0$, $x \in \mathbb{R}^N$) of the original Cauchy problem. The author thanks A. A. Samarskiy and S. P. Kirdyumov for steady interest and helpful discussions. Figure 1, references 25: 17 Russian, 8 Western. [21-2415]

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